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OPTICAL GAIN MEASUREMENTS AND DEVELOPMENT STUDIES OF VISIBLE CHEMICAL LASER SYSTEMS

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ABSTRACT

Chemiluminescence spectra and laser cavity gain measurements have been made on chemical reactions thought to have promise for visible lasing. A shock tunnel apparatus capable of producing hot flows for periods of milliseconds was used for the experiments.

Group II metals (magnesium, strontium and calcium) reacted with carbon monoxide and nitrous oxide resulted in bright band chemiluminescence, and low excited state yields. The low yields appear to be due to electronic state quenching. A new ultraviolet band of MgO was observed.

Magnesium-fluorine reactions repeated the previously observed abnormal population distributions, but no significant laser gain was observed.

Xenon excimer radiation resulting from chemical reaction was observed to be very bright, and possible laser gain was implied by the relative intensities of the output light polarized normal and parallel to the Brewster window axes.

Diatomic excited sulfur B-X radiation from chemical reactions was observed in detail, but no gain was observed.

There appear to be two areas of difficulty associated with generating visible laser radiation associated with this apparatus. Quenching of excited states can be very rapid at the high densities (Argon at 10^{19}/cc, active species at levels of 10^{17}/cc). Secondly, as indicated in an appendix, refractive effects due to gas density gradients appear to restrict the cavity Q even more than the mirrors. Deflections of 5 milliradians were observed. Due to these effects, it is not possible to eliminate all the above reactions as active candidates.

I. INTRODUCTION: HISTORY AND OBJECTIVE

Chemiluminescence from metal oxidation reactions has been studied by Xonics[1] and several other groups for the purpose of making a visible wavelength chemical laser. In the immediately prior contract to Xonics, a survey of chemiluminescence spectra was compiled using the shock tunnel apparatus similar to that described in Appendix A. Twenty-six metals were reacted with one or more of four oxidants. We concluded that some of these systems deserved more detailed investigation; most deserving was the Mg-F_2 system. The subject contract was conceived to allow the more detailed investigation of the MgF system, of SiO and GeO metastable systems, and of the possibility of a GeO-Na transfer system.

Shortly before the inception of the present contract, Benard and others at the University of California at Santa Barbara showed that the addition of CO to the Mg, Ca, Sr-N_2O systems greatly increased the luminescence. In the first months of this program we verified that many of their results applied to the higher density regime of our apparatus. In the closing months of the contract we proceeded to examine chemical pumping of XeF and KrF excimer systems, and of the S_2^* system.

The objective in all of this has been to provide the knowledge required to make a visible chemical laser.

The body of the report describes the results of those measurements on the systems listed above. The appendices describe the apparatus and specific supporting studies. The list of runs concludes the report.

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[1] P. B. Scott, R. Blair, S. E. Johnson and G. W. Watson, "Final Report on Laser Screening Experiments", Xonics TR-59 (Nov 1975).

II. ALKALINE EARTH METAL - N_2O-CO STUDIES

In the past two years Benard and others[2-6] have studied the reaction scheme

$$M + N_2O \rightarrow MO + N_2$$

$$MO + CO \rightarrow CO_2 + M(^3P)$$

$$M(^3P) + N_2O \rightarrow MO^* + N_2$$

For present purposes, M represents Mg, Ca and Sr atoms (obtained by shocking the hydride or oxide). The oxidation reaction yields[6] MO - highly vibrationally excited metal oxide - which is reduced to metastable metal atoms by the CO. These ^3P atoms then in turn reduce the N_2O forming electronically excited metal oxide.

The resulting chemiluminescence is shown for the metals Mg and Ca as Figures 1 and 4.

The magnesium spectrum is presented in three segments, the ultraviolet, green and red, as the plate shows nothing of pertinence between. At left is the band of most scientific interest, as it has not previously been observed. Calculations by Scamps and Lefebvre - Brian suggest a $^3\Sigma - {}^3\pi$ transition with the O-O band at $3600^{\pm 100}$ Å, which we use tentatively as the assignment. There is no assurance that this is not an impurity band, but the more obvious possibilities (including CaO, BeO, AlO, SrO) have been eliminated as having no known band systems of the observed configuration. The mercury 3650Å system is from the room lights. The $d^3\Delta - a^3\pi$ transition at 3721Å was recently assigned[8-9] by Evans and Mackie. At center, the forbidden Mg 4571Å line appears strong despite its 4.5 ms lifetime[10]. The impurity line due to Strontium reflects its prior use in the shock tube. The MgO B–X system is clear, but the $B\,^1\Sigma - A\,^1\pi$ bands - known to range from 5285 through 6580Å - appear to contribute a large background continuum with only the 0,0 bands clearly discernible.

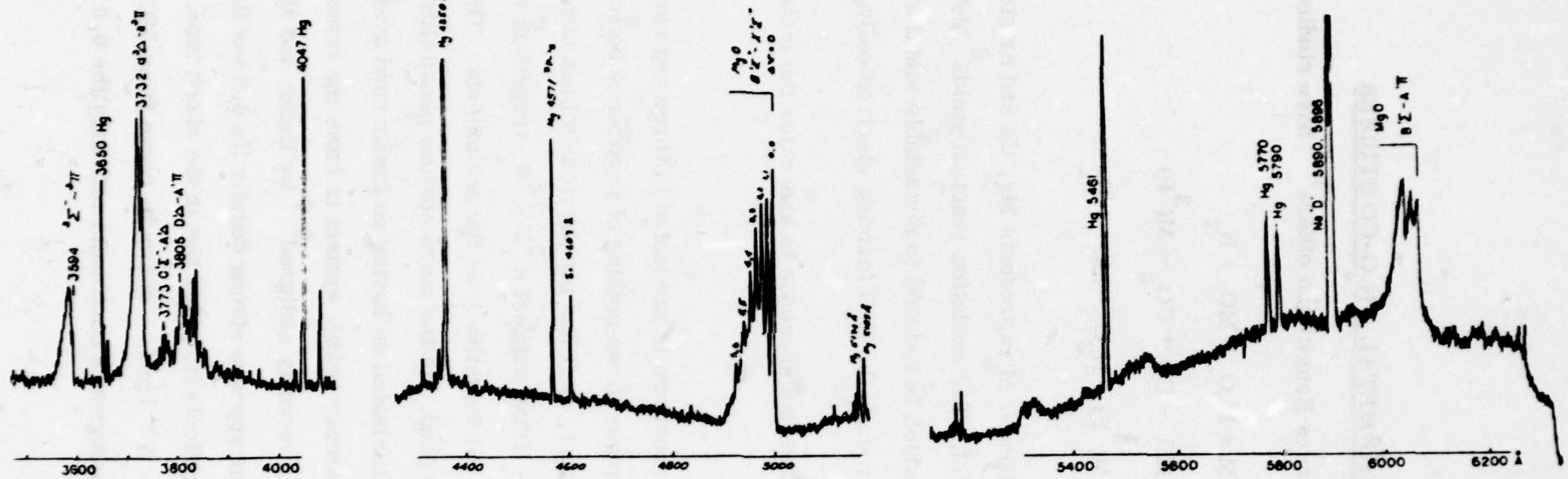

Figure 1. Densitometer trace of plate 760924, Mg + CO + N_2O.

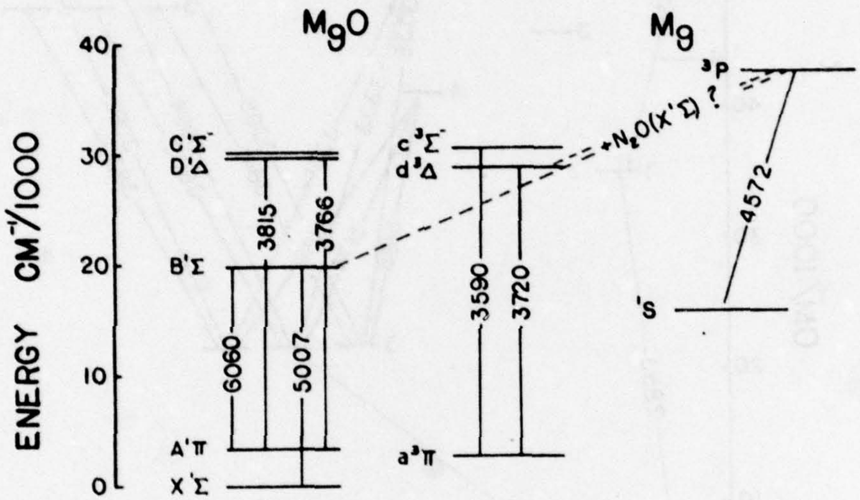

Figure 2. Correlation diagram (after Benard & Shafer[4]) for the Mg-N_2O reaction. Energy levels are referred to MgO + N_2 ground states. The $a^3\pi$ energy level is from Evans & Mackie[9], the $^3\Sigma^- - ^3\pi$ energy derived from our data is added to it to give the $^3\Sigma^-$ level. The production of $^1\Sigma$ and $^3\pi$ MgO from N_2O + Mg(^3P) has been proposed by Benard and Shafer[4].

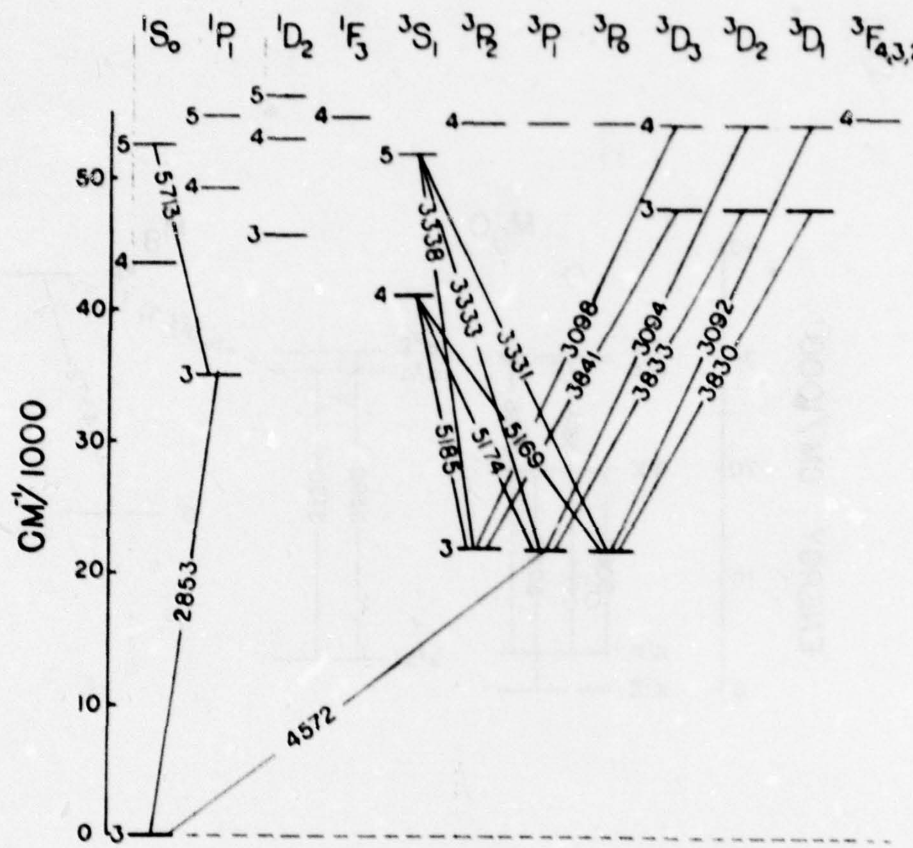

Figure 3. **Energy level diagram of MgI. Only transitions in the spectral range of the present study are shown. Wavelengths (in Angstrom units) are derived from NBS 35 "Atomic Energy Levels" (1971).**

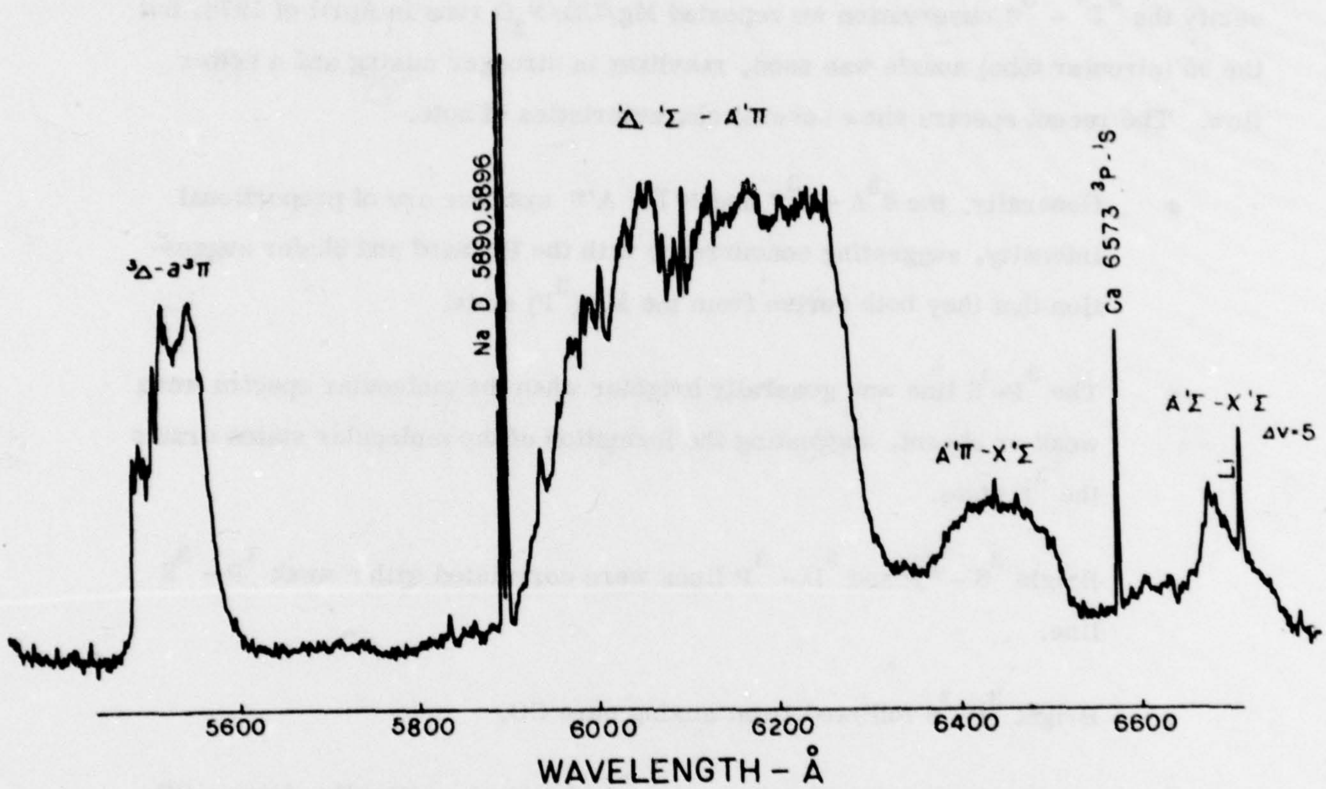

Figure 4. Densitometer trace of plate 760831, $CaH_2 + CO + N_2O$. See text for the origin of assignments.

Figure 2 gives a correlation diagram for Mg and MgO levels of interest. We include a suggested level for the $^3\Sigma^-$ state by use of the observed $^3\Sigma$ - $^3\pi$ band head at 3590Å and the published[8] level of the $^3\pi$ state. The atomic levels are shown in Figure 3 in more detail.

The Mg spectrum of Figure 1 was obtained with the contoured #4 nozzle. To verify the $^3\Sigma^-$ - $^3\pi$ observation we repeated Mg/CO/N_2O runs in April of 1978, but the #5 (circular tube) nozzle was used, resulting in stronger mixing and a hotter flow. The recent spectra show several characteristics of note.

- Generally, the $d^3\Delta$ - $a^3\pi$ and $B'\Sigma$ - $A'\pi$ systems are of proportional intensity, suggesting concurrence with the Bernard and Shafer suggestion that they both derive from the Mg (^3P) state.
- The ^3P-^1S line was generally brighter when the molecular spectra were weak or absent, suggesting the formation of the molecular states drains the ^3P state.
- Bright ^3S - ^3P and ^3D - ^3P lines were correlated with a weak ^3P - ^3S line.
- Bright ^3P-^3S followed from mixing pure CO.
- Bright allowed atomic lines and bands followed, generally, from a CO-argon mix with only 10% the argon of the above.

The phantom lines in Figure 2 show the possible nature of the third reaction. it is evident that only one of the transitions, that to $d^3\Delta$ state obeys spin conversion, as discussed by Benard and Shafer[4].

In the work of Benard a metal atom density of ~ 3 x 10^{14}/cc was attained in a subsonic flame, and about 1% of these were converted to Mg(^3P). In the shock tube

the flow downstream of the nozzle is of Mg density 10^{17} atoms/cc.† By measurement of the luminosity of the mixing zone we conclude the density of Mg(^3P) is in the range of 10^{13}/cc, larger in absolute terms than in the slow flow experiment but a much smaller percentage of the available magnesium.

Calcium

In our earlier work[1] we observed only diffuse and weak spectra from the reaction of Ca + N_2O. The spectrum observed by mixing CO with the CaH_2 powder, shocking, and injecting N_2O during the expansion is shown as Figure 4. Band identifications are those proposed by Benard, Shafer and Hecht[3] and Benard, Shafer, Love and Lee[6]. Once again, the forbidden ^3P-^1S line is strong despite the fast flow. The A-X assignments are from Capelle[11].

The calcium system was the first examined for gain by the polarization method (App. B). The maximum ratio $E_{\parallel}/E_{\perp} \cong 6$ lead to the conclusion that there was no gain at λ = 5500Å or at 6160Å. A schematic of the experimental arrangement for these measurements is given as Figure 5.

By use of a flash lamp at one end of the flow nozzle and the spectrograph on the other end, absorption measurements were made. A broad absorption line at 4227Å was observed as a result of the ^1S-^1P absorption. (An energy level diagram for Ca is given by Herzberg[12], pg. 77.) The lack of evident absorption in the 4400Å region implies that the metastable population is much less than that of the ^1S ground state.

The meaning of the gain measurements is obscured by an apparent absorption, possibly due to scattering, that was measured with a helium-neon laser and mirrors setup for 4 passes through the flow region. Even after the reflected shock, the laser beam was attenuated about 4% per pass. In Appendix C we discuss the effect of flow turbulence on the optical path, which appears to be a suitable explanation. The attenuation was not significantly decreased by deleting the CaH_2 powder, it is proportional

†Calculated assuming total vaporation.

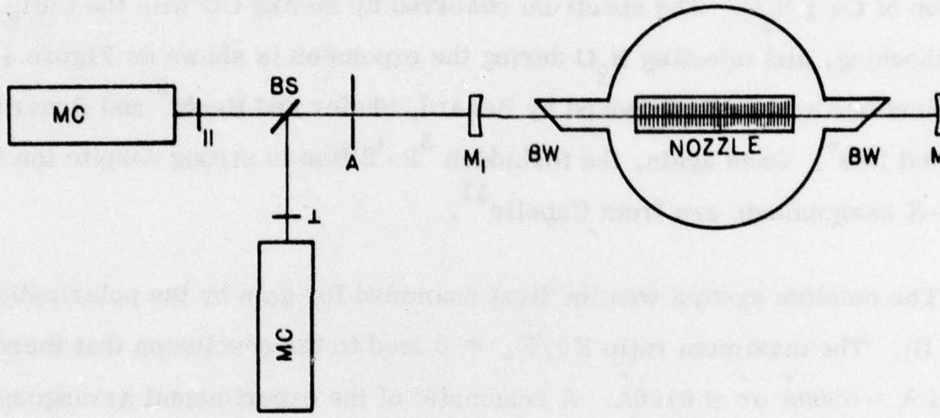

Figure 5. Apparatus for measuring the ratio of cavity output light in the ∥ and ⊥ polarizations. Laser mirrors M_1 and M_2 and Brewster windows BW form an optical cavity for light emitted by the active medium flowing from the nozzle. Light is transmitted by M_1 (about 1% transmission) to be collimated by the aperture, divided by the beam splitter, and the parallel (∥) and (⊥) components are respectively transmitted by the Polaroid filters to the monochrometers MC. The relative monochrometer outputs with M_2 blocked and reflecting imply the gain or absorption of the cavity. See Appendix B.

to the driver pressure. (The 4% attenuation was at 100 psi driver, 60 torr of CO in the injection tank.) Simultaneous measurement of the laser beam attenuation and the cavity loss, as indicated by the ratio of polarized components ($E_{\parallel}/E_{\perp}$), showed that as the attenuation decreased the cavity loss also decreased.

Prior difficulties with fluorine contamination (described in the next paragraph) lead to the possibility that the broad and complex system marked as $^1\Delta$, $^1\Sigma$ - A' $^1\pi$ bands may be due, in part, to the $A^2\pi - X^2\Sigma$ band of CaF. Evidence to the contrary is 1) the adjacent $B^2\Sigma - X^2\Sigma$ band of CaF is absent, and 2) the prominent band heads of A-X CaF generally do not match the spectrum of Fig 4.

Strontium

In our prior work strontium was reacted only with fluorine[13]. Intense B-X and A-X bands were observed in the yellow and red. In the first experiments of the present contract we reacted SrO or SrH_2 with CO and N_2O so as to observe SrO. Rather than SrO we observed strong SrF bands. Three weeks were expended in an attempt to isolate the source of fluorine to no avail, it is probably an impurity in the SrO and SrH_2. The observed intensity leads to the belief that transfer processes were active in exciting the SrF.

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[2] D. J. Benard, W. D. Shafer and P. H. Lee, Efficient chemical production of metastable alkaline earth atoms, Chem. Phys. Lett., 43, 69 (1976).

[3] D. J. Benard, W. D. Shafer and J. Hecht, Chain reaction chemiluminescence of alkaline earth catalyzed N_2O-CO flames, J. Chem. Phys., 66, 1012 (1977).

[4] D. J. Benard and W. D. Shafer, Mechanism of chemiluminescent chain reactions in Mg catalyzed N_2O-CO flames, J. Chem. Phys., 66, 1017 (1977).

[5] D. J. Eckstrom, J. R. Barker, J. G. Hawley and J. P. Reilly, Intracavity dye laser spectroscopy studies of the Ba + N_2O, Ca + N_2O + CO, and Sr + N_2O + CO reactions, App. Optics 16, 2102 (1977).

[6] D. J. Benard, W. D. Shafer, P. J. Love and P. H. Lee, Modulated transmission spectroscopy of gaseous chemi-excited Ca and Sr monoxides, App. Optics, 16, 2108 (1977).

[7] J. Scamps and H. Lefebvre-Brian, SCF calculations of the electronic states of magnesium monoxide, J. Chem. Phys., 56, 573 (1972).

[8] J. Scamps and G. Gandara, A ${}^3\Delta - {}^3\pi$ transition in the near-ultraviolet spectrum of MgO, J. of Molecular Spectroscopy 62, 80 (1976).

[9] P. J. Evans and J. C. Mackie, MgO Triplet-Triplet Transitions and Intensities, J. of Molecular Spectroscopy 65, 169 (1977).

[10] P. S. Furcinitti, J. J. Wright and L. C. Balling, Phys. Rev. A12, 12 (1975).

[11] G. A. Cappelle, C. R. Jones, J. Zorskie and H. P. Broida, "Photon yields and spectra resulting from reactions of Ca with oxidants", J. Chem. Phys. 61, 4777 (1974).

[12] G. Herzberg, Atomic Spectra and Atomic Structure, Dover (1944).

[13] S. E. Johnson, P. B. Scott and G. Watson, Visible Chemiluminescence and Pulsed Chemical Laser Study, Xonics TR-48 (December 1973).

III. MgF

In our prior contract we obtained spectral data indicating an inversion of the high vibrational levels of the $A^2\pi$ state of magnesium fluoride. The addition of mirrors to form a laser cavity caused an enhancement of the (16,15), (16,16) and (16,17) transitions.

$Mg + F_2$ flame studies by Steinberg et. al.[14] also showed the selective excitation of the high vibrational level of MgF. However, resonant enhancement of the (16,15), (16,16) and (16,17) transitions was no more than that of the lower levels, in contrast to the observations of shock tube flows at Xonics.

The amount of energy necessary to populate $A^2\Sigma$, $v' = 16$ is about 38000 cm^{-1}, which exceeds by some 11000 cm^{-1} the amount available through the reaction

$$Mg + F_2 \rightarrow MgF + F. \qquad (1)$$

Since the dissociation energy of MgF is also about 38000 cm^{-1}, a likely excitation mechanism is the atom-atom combination reaction

$$Mg + F(+M) \rightarrow MgF^*(+M) \qquad (2)$$

where the third body M may or may not be necessary. Reaction (1) could serve as a precursor to (2) by generating the F atoms.

In the present work we experimented extensively with powdered $Mg + SF_6$ shocked in an argon bath. We observed the resulting MgF A-X radiation in the form of spectra and by using monochrometers set to observe radiation from particular wavelengths of interest as a function of time. Selective excitation of the high vibrational levels was again observed. More of the selective excitation of the high levels was observed by shocking $Mg + SF_6$ in argon than by injecting F_2 into Mg + Ar downstream of the nozzle. This confirms earlier results and supports Eq. III-2 as the source of the (v'=16) $A^2\pi$ MgF.

As an alternate source of fluorine we substituted C_2F_6 for SF_6 with similar results. The C_2F_6 appears to offer more selectivity and brigher luminescence. We also demonstrated MgF bands obtained by shocking 3 parts MgF_2 + 1 part Mg powder. The bands were quite sharp and, again, were weighted to the high v'.

In all these tests with upstream introduction of fluorine (with SF_6, C_2F_6 and MgF_2) a simple two-dimensional deLaval nozzle of 2mm-4mm nozzle width was used.

High reflectivity ($T \cong 0.5\%$) dielectric laser mirrors were purchased specifically for the MgF application, their bandpass of 3400-3600Å just matches the bands of interest. These mirrors were aligned to the nozzle by first aligning a He-Ne (6328) laser beam with the nozzle, then putting the laser mirrors on and tuning with a photo diode. Mirror alignment produces cavity ringing, observed on an oscilloscope as an oscillation. Numerous runs with these mirrors failed to show any indication of lasing, or even to produce enough light output through the mirrors to expose a plate in one or a few shots. Monitoring of the $\parallel$ and $\perp$ components failed to show any significant signs of gain.

During some of these measurements the attenuation of a He-Ne laser was used to evaluate the optical quality of the cavity. A 2-10% loss per pass was observed. This, it now appears, was at least in part due to path bending due to $d\rho/dx$ in the slot type of nozzle (App. C).

Figure 6 is a densitometer trace of one of the runs with Mg + SF_6.

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14. M. Steinberg, Y. M. Kudryavtsev and P. H. Lee, "The Development of Flame Chemical Lasers", Final Report on ARPA Contract DAAH01-75-C-0339, U. of California, Santa Barbara, Ca., (Sept 1976).

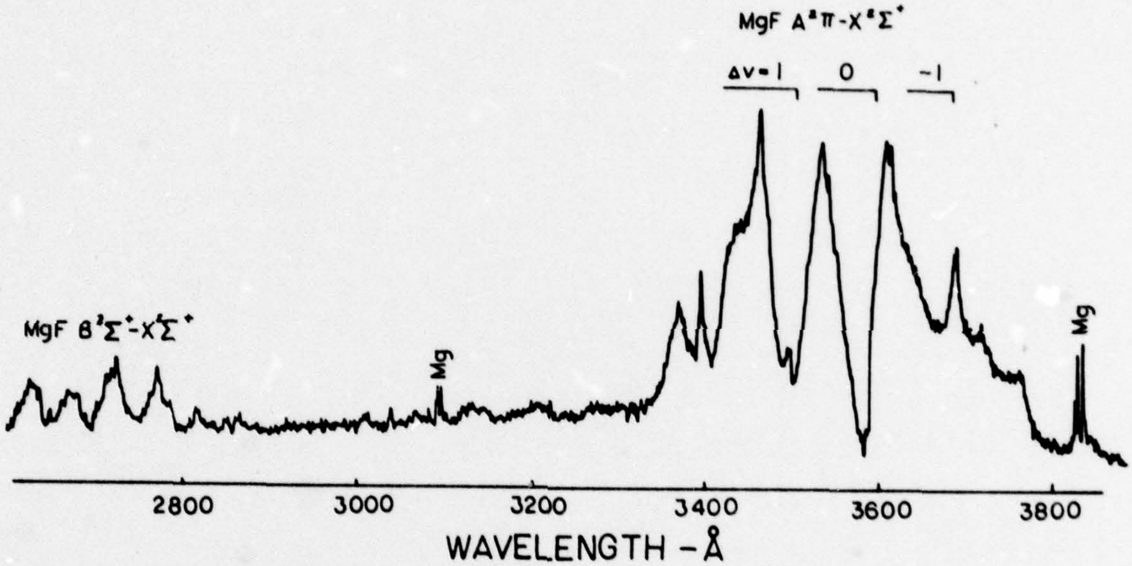

Figure 6. Densitometer trace of 77021705; 100 mg Mg, 1 torr SF_6, 29 torr Ar, 50 psia driver.

IV. OBSERVATIONS WITH SILICON AND GERMANIUM

The group IV elements have appeared to have particular potential for a chemical laser, if we could learn how to utilize the metastable states formed upon reaction with oxidizers. We again were unable to observe those states.

SiO

Forbidden bands of SiO have been repeatedly observed by others[15], whereas we have not observed them. This is probably due to our very high flow speed in the nozzle exit area. Again we have attempted to see the SiO $a^3\Sigma^+ \rightarrow X^1\Sigma^+$ and $b^3\pi - x^1\Sigma^+$ with a negative result. The $D^1\pi - X^1\Sigma^+$ bands, line structure and noise overwhelm any radiation from metastable states.

GeO

Spectra of Ge + N_2O reaction chemiluminescence were examined, in the hope of finding $a^3\Sigma - X^1\Sigma$ bands, with a negative result. Using a standard lamp calibration of the monochrometer system and the published lower limit on lifetime of 2 ms[16] we estimate the $a^3\Sigma$ population to be on the order of 10^{13}/cc or less in a Ge atom density of 10^{17}/cc in the nozzle flow. In a similar study, Cappelle and Brom[17] measured a photon yield of order 10^{-3} photons/atom. The upper limit we observe is one factor of ten below Cappelle's observation, as would be expected due to the higher flow velocity in our supersonic flow. We made no measurements in the far UV to search for the $b^3\pi$ bands that Cappelle observed. Preliminary gain measurementson the a-X system showed results similar to CaO. This was not pursued further.

Whereas we had hoped to transfer from GeO* to an atomic species such as sodium, the low density of GeO* discouraged extensive work in that area. Preliminary measurements showed the presence of Ge to enhance the sodium D lines, confirming that transfer does occur. Whereas the $^2D-^2P$ and $^2S-^2P$ lines @ 5684, 5690 and 6156, 6162 (which feed the D lines upper state) did appear on the Polaroid

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(ASA 3000) spectra they were not exceptionally bright and there seemed to be not near enough intensity to apply the $\parallel/\perp$ gain measurement technique.

It was also suggested that the sodium population is lost to the reaction $Na + N_2O \rightarrow NaO + N_2$, which is exothermic by 1.7 ev., but there is no evidence to support this reasonable conjecture.

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15. G. Hager, R. Harris and S. G. Hadley, "The $a^3\Sigma^+ \rightarrow X'\Sigma^+$ and $b^3\pi - X'\Sigma^+$ band systems of SiO and the $a^3\Sigma^+ \rightarrow X'\Sigma^+$ band system of GeO observed in chemiluminescence", J. Chem. Phys. 63, 2810 (1 Oct 1975).

16. B. Meyer, J. J. Smith and K. Spitzer, "Phosphorescent Decay Time of Matrix-Isolated GeO, GeS, SnO and SnS and the Lifetime of the Cameron Bands of CO-type Diatonics", J. Chem. Phys. 53, 3616 (1970).

17. G. A. Cappelle and J. M. Brom, Jr., "Reaction of germanium vapor with oxidizers: Photon yields and a new GeO band system", J. Chem. Phys. 63, 5168 (1975).

V. CHEMICALLY EXCITED EXCIMERS

Electron beam and discharge pumped excimer lasers have become very popular in recent years, and it is of interest to see if excimer light emission and lasing can be obtained by chemical means - with no electrical input. By using a pre-mixture of 10% Xe in argon in the injection tank and injection of fluorine with the #4 nozzle, a bright continuum ranging from 2500–3600Å with peak brightness at ~ 3500Å was observed. By adding 3600Å band mirrors (with about 1/2% transmission from below 3500Å to above 3600Å) the ratio $E_{\parallel}/E_{\perp}$ could be measured with a result of values of typically 16. The luminescence was sufficiently bright that spectra of the light transmitted by the mirrors from the cavity could be recorded. They showed no pronounced line narrowing. Figure 7 shows a typical spectrum and the spectrum after adding the laser mirrors. We ascribe the broad continuum to XeF, with no Xenon or no fluorine only a line spectrum remains.

Single pass He-Ne laser attenuation under these conditions showed attenuation (or scattering, as deflection of the beam caused the same output as attenuation) as high as 10% with a 150 psi driver and about 1-2% with 50 psi driver. We presume this to be due to flow turbulence. With the double apertured laser beam that was used, a deflection of 10^{-3} radians would be read as ~ 50% attenuation.

Substitution of Kr for the Xe resulted in weaker continuum emission in the 3000-3600Å region and at $2450^{\pm 50}$ Å, with many lines superimposed.

Substitution of neon for the "inert" gas argon yielded brighter spectra. This could be expected as the argon is known to be responsible for significant quenching[18], and neon is expected to be a less effective quencher.

Quenching due to impurities in the shock tunnel was also very important, cleaning of the tube, tanks and nozzle being required to get the brightest spectra.

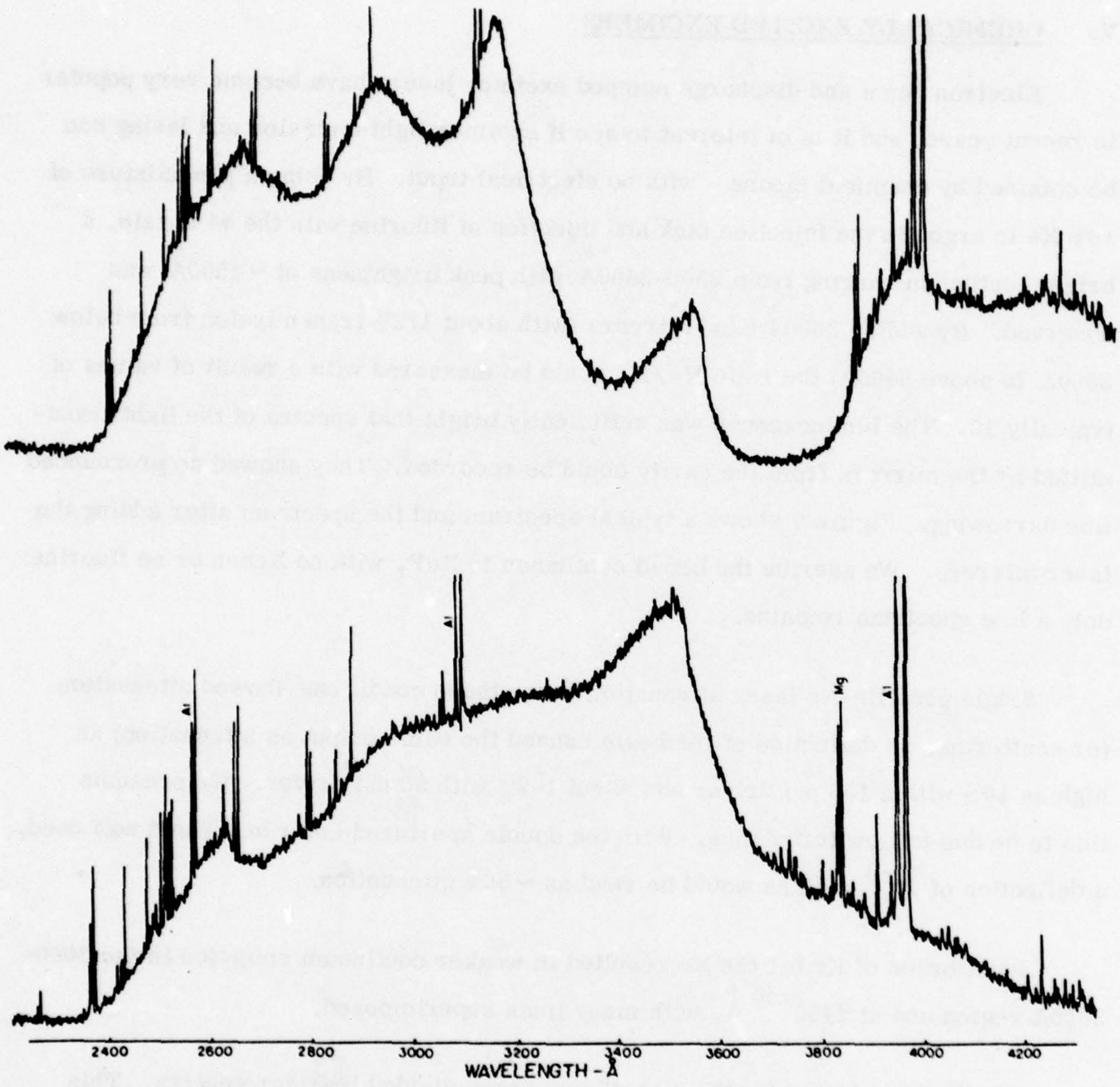

Figure 7. Densitometer traces of 770404 with and without mirrors; 77040501, 35 psia F_2, 150 psi driver, Ar/Xe @ 44/1 torr; 77040502, 4, 5 - mirrors on.

As we had an operating discharge excimer laser, we compared the brightness of the luminescence of the chemical source with that of the discharge source (de-tuned so that it did not lase) and found the discharge source to be 5000 times as bright. (Since the discharge duration is ~ 10 ns, the total number of photons is much larger for our chemical source, but the fast pulse capability of the electrical discharge allows the greater brightness.) As the electrical source has enough gain to lase with a single mirror, it is reasonable to expect part of the factor of 5000 is due to stimulated emission. By this argument, it appears that our chemical source is within a factor of ten of lasing with $T < 1\%$ mirrors. By means of the $E_{\parallel}/E_{\perp}$ measurements, it appears that we were very close to lasing (see App. B) and that probably only the flow turbulence prevented it (App. C).

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18. J. G. Eden, R. W. Waynant, S. K. Searles and R. Burnham, "New Quenching Rates Applicable to the KrF Laser", Appl. Phys. Lett. 32, 733 (1978).

VI. SULFUR $B^3\Sigma_4 \rightarrow X^3\Sigma_g^-$ COMBINATION RADIATION

Laser action on the B-X transition of the sulfur molecule was achieved by Leone[19] by means of optical pumping with either a nitrogen or frequency-doubled dye laser. Laser action was observed from 3650-5700Å. As pointed out by Leone, this new laser system has the advantages of wide tunability, is scalable and offers also the possibility of non-optical pumping.

Figure 8 represents the potential surfaces of diatomic sulfur. It is evident that the lower states of the B state are displaced from those of the ground state and lie over its high vibrational levels. In the Leone experiment[19] the ground state sulfur is pumped to v' of 3-7 by a dye laser of a 2 μs pulse of over 100 μJ energy, and the S_2 laser pulse follows the time duration and shape of the pump pulse. Using Leone's numbers we estimate that the instantaneous threshold columnar density of excited sulfur molecules is $\sim 5 \times 10^{14}/cm^2$. Densities of this level are easily attained in the shock tunnel nozzle flow, and so we proceeded to study this system for the purpose of demonstrating chemically excited S_2 lasing.

A. Sulfur Sources

By shocking the following sulfur sources mixed in Argon (or similar inert gas) and expanding through a nozzle we observed:

COS - Bright banded continuum ranging from 2800-4500Å. This appears to be the best S_2* source and will be discussed in some detail.

H_2S - Also a bright source, bands are less distinct than with COS, more lines.

SF_6 - Requires faster shock, not as bright as either H_2S or COS.

$SF_6 + H_2S$ - No notable improvement over individual components.

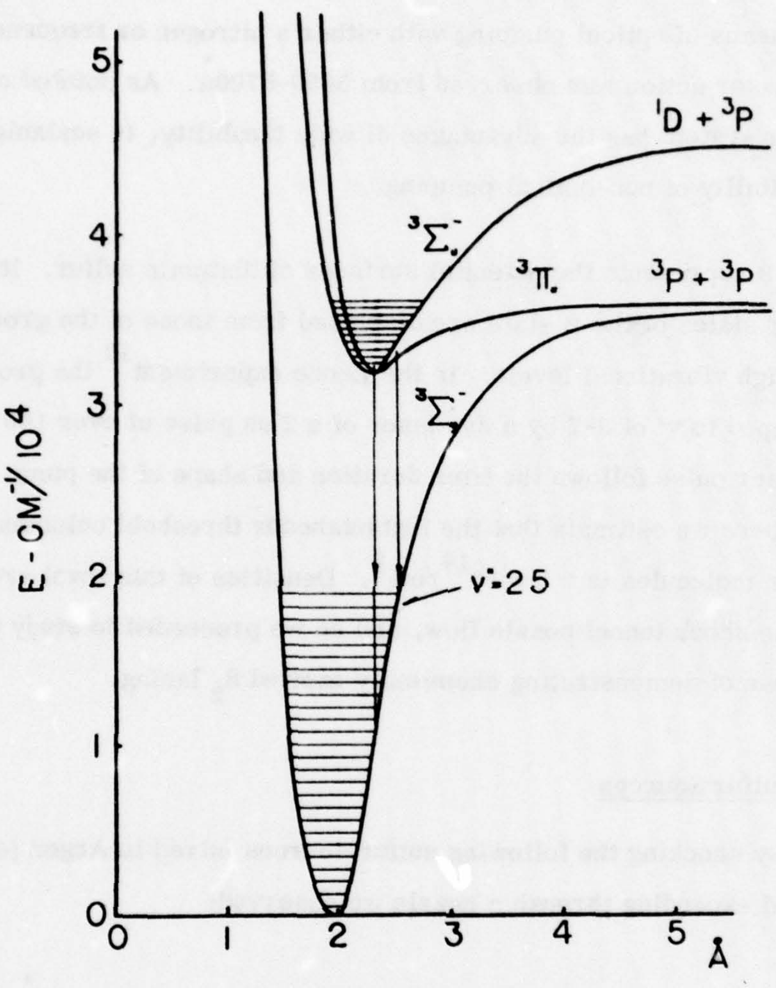
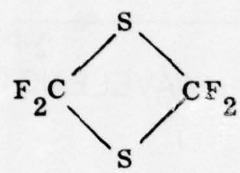


Figure 8. Illustrating the potential energy versus interatomic distance of diatonic sulfur. From ref. 19.

$SF_6 + SiH_4$ - Suggested by Professor S. Bauer, exothermic, light loads lead to weak S_2* B→X, with SiF* A-X and B-X. Heavier loads (preshock sulfur density $[SF_6] > 10^{17}$/cc) create bright luminescence showing the S_2* brighter than SiF*. Figures 9 illustrate the spectra that result.

$C_2F_4S_2$ - Tetrafluoro-1,3-dithietane, from PCR Research Chemicals, of form

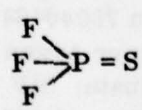


This is one of several chemicals suggested that were expected to have more weakly bound Sulfur than COS (D(OC-S) ≤ 3.71 ev), in the expectation of getting faster sulfur release at lower temperature.

Several spectra, taken on polaroid film, showed CN $B^2\Sigma^+ - X^2\Sigma^+$ stronger than the S_2* radiation, which was weak as compared to that from either COS or $SiH_4 + SF_6$.

$CH_3)_2S$ - Dimethyl Sulfide (Me_2S) - Worst source of S_2*, very weak bands only with strong (M = 6.1) shock.

$(CH_3)_2$ Si - Dimethyl Disulfide (Me_2S_2) - Of structure CH_3-S-S-CH_3. Not much better than Me_2S.

F_3PS - of structure 

Professor Bauer also suggested this, and indicated how to generate it since it is not commercially available. We chose not to try it, only because the COS was a useful source and we questioned whether the time required would pay off.

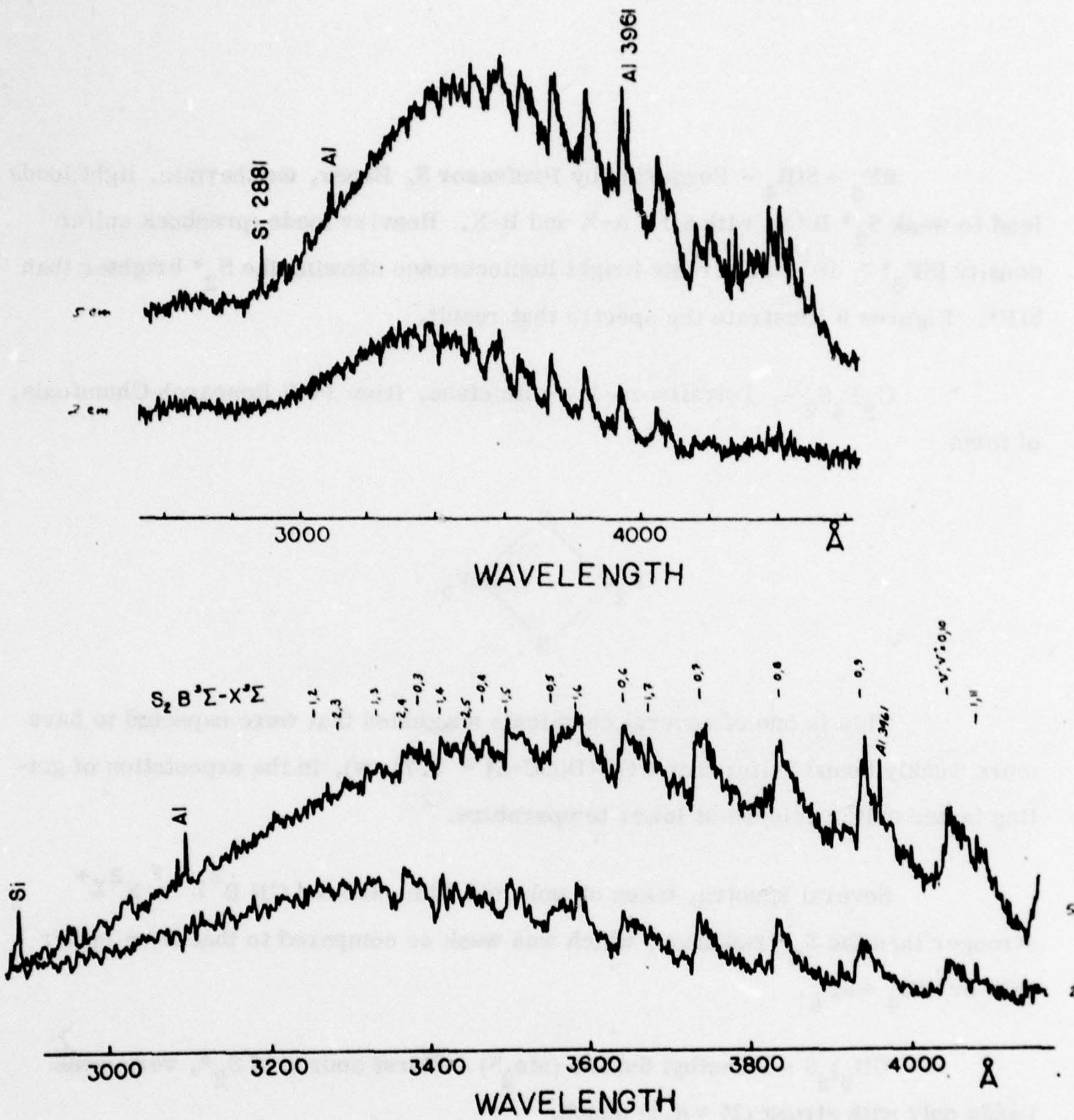


Figure 9. **Spectra obtained by shocking $SiF_4 + SF_6$. Run 78040401 at bottom; 100 psi driver, 5 torr each SiH_4 and SF_6, 200 torr Argon in injection tank; M ≅ 5.3. Run 78040404 at top; 200 psi driver, 5 torr each SiH_4 and SF_6, 440 torr Argon in injection tank; M ≅ 5.4. Sulfur B to X bands dominate; SiF $A^2\Sigma^+ - X^2\pi$ bands are at right, with 0,0 band heads @ 4368 and 4400. A portion of the S_2* bands are shown with expanded scale to illustrate the rotational structure.**

B. Combination Radiation from COS

The pertinent reactions are:

$$COS + M \rightarrow CO + S(^1D) + M \qquad (D(OC\text{-}S) \leq 3.71 \text{ ev})$$

$$S(^1D) + S(^3P) + M \rightarrow M + S_2(B^3\Sigma)$$

As is evident from Figure 8, the presence of ^1D sulfur is essential. Electronic quenching to the ^3P state occurs by collision with either CO or COS[20], with respective rate constants of 2.2 and 8×10^{11} cm^3/molecules/sec.

An alternative channel for production of B state sulfur could be by collisional dissociation of the COS to the more energetic $S(^1S)$ and then - by analogy to OCSe[21] - reaction with OCS:

$$COS + M \rightarrow CO + S(^1S) + M$$

$$S(^1S) + COS \rightarrow CO + S_2(B^3\Sigma)$$

As the last reaction is spin forbidden, and as $S(^1S)$ is 1.6 ev more energetic than $S(^1D)$ its creation by thermal dissociation behind the reflected shock wave is much less likely. The equilibrium dissociation is illustrated in Figure 10. The Lighthill theory of an ideal dissociating gas was used in the calculations represented by Figure 10, α^* is expected to be accurate to within 20%. (The degree of dissociation α^* = number of dissociated atoms of species S/total number of S atoms.) The effect is even more pronounced as the added activation energy required to accomplish spin conversion is not included in the equilibrium calculation. Thus we expect virtually all the $S_2(B \rightarrow X)$ radiation to originate in the first pair of reactions.

Figure 11 shows spectra observed from Ar + COS products flowing through the slit nozzle mounted in the old (side flow) configuration. Similar spectra have been

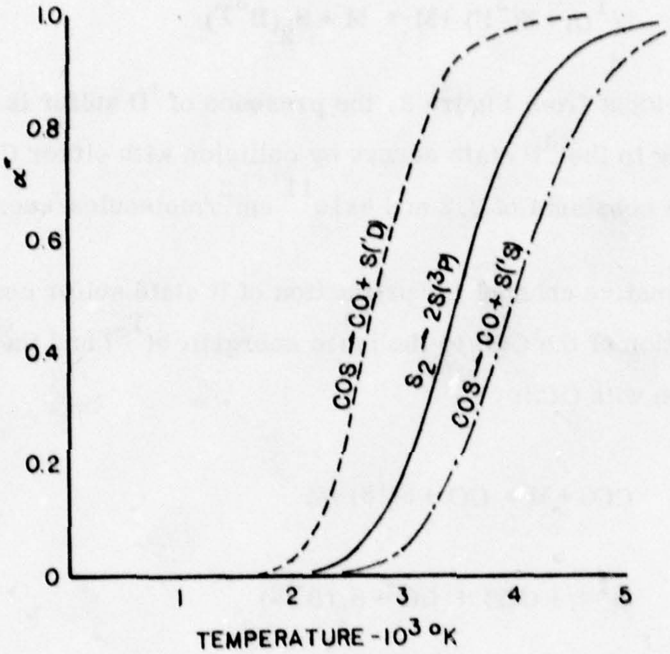


Figure 10. The equilibrium degree of dissociation α^* of COS and S_2 as dependent on temperature. These curves represent approximate calculations based in the Lighthill "ideal dissociating gas". If the COS is in a bath of Argon, an M = 5 shock heats it to ~2600°K, causing 30% dissociation into the $S(^1D)$ state. The reflected shock more than doubles this temperature.

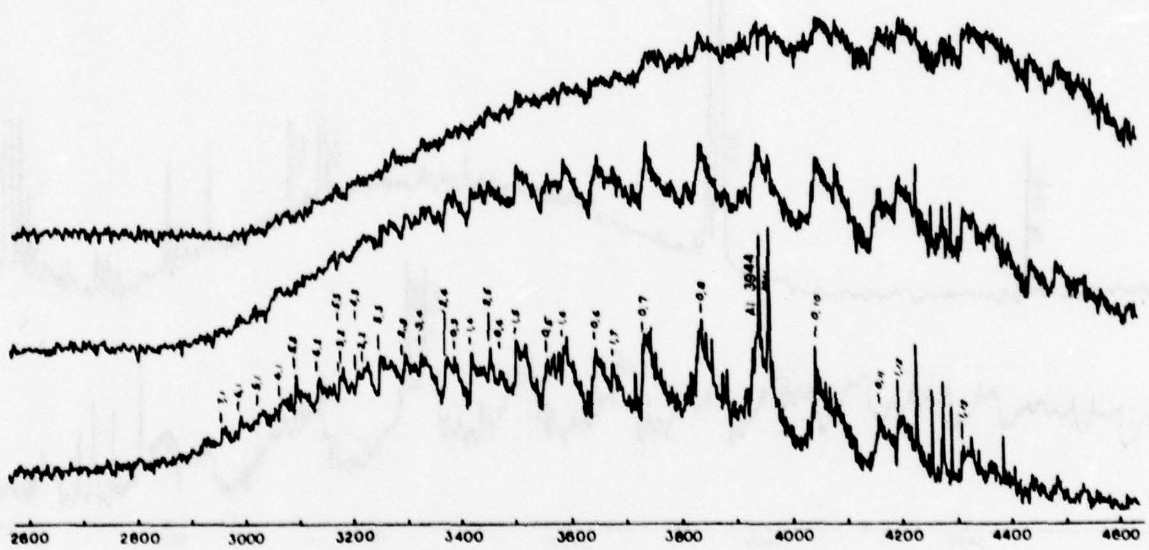


Figure 11-a. Densitometer traces of spectral plates obtained by shocking Ar + COS and expanding through a (side mounted) slit nozzle. Driver loaded to 100 psia. At bottom is run #78032801, P_1(COS) = 1.7 torr. Center is run #78032802, P_1(COS) = 3.3 torr. At top is run #78032803 with P_1(COS) = 6.7 torr. Note the shift to long λ with larger loadings.

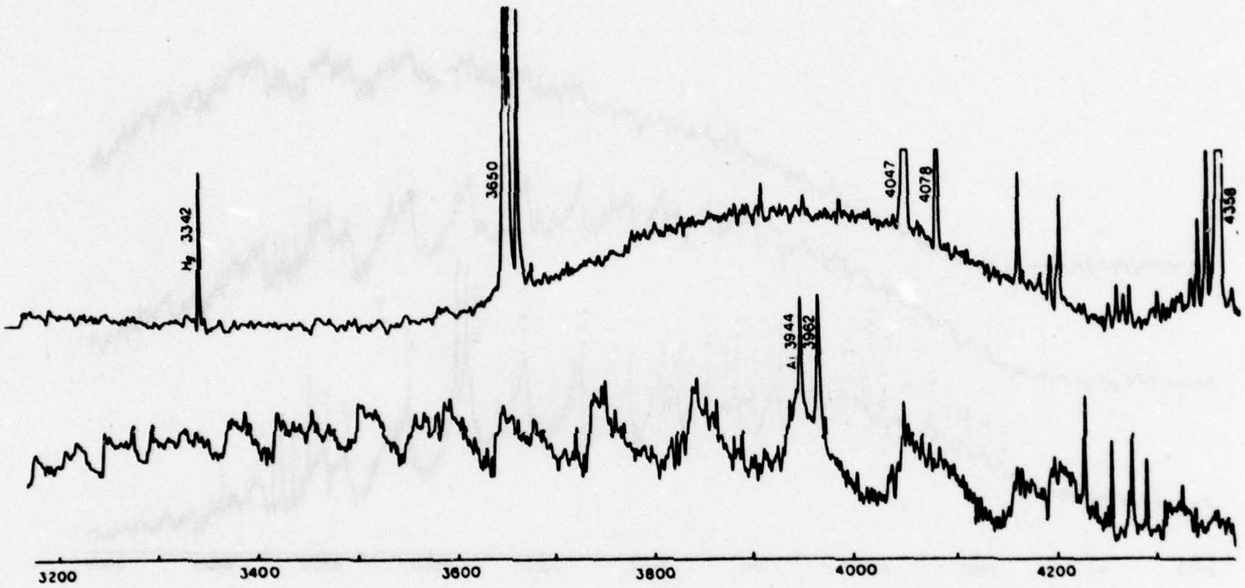


Figure 11-b. At bottom is an expanded portion of the spectrum of run #78032801 showing the structure that is obscured in Figure 11-a. At top is the reference trace from a mercury lamp.

observed from the new transition duct nozzle. Band heads have been identified, the lower vibrational levels of the B state are most heavily populated and decay to the intermediate vibrational levels of the ground state. Note that the upper traces, obtained from heavier loadings of COS, show the spectra shifted toward large wavelength. This can be attributed to the larger densities of ground electronic state S_2 in the lower vibrational states, which lead to absorption of short wavelength emission. By this mechanism the gas becomes a "gray body" for short λ well before it does at large wavelength. For loadings of about five times those illustrated the short wavelength region can show S_2 absorption bands.

Vibrational relaxation of the B state leads to a similar result, as it depletes the upper v' states that contribute strongly to the radiation in the 3000-3500Å region. Recent results by Caughey and Crosley[23] show that the vibrational relaxation of B state sulfur by Argon has a cross section of 14×10^{-16} cm^2, and hence that the lifetime of an excited vibrational B state is about one nanosecond in the expanding flow, well under the electronic lifetime of 40 ns. This helps to explain the result of Figure 9, where a similar shift to the red is observed as the Argon pressure is increased.

Addition of some gases notably change the spectrum. In Figure 12, for instance, note the effect of adding 10 torr of N_2O (in the injection tank, about 3 torr before being shocked) to the 10 torr COS 200 torr Argon pre-mix. The N_2O causes short wavelength transitions ranging from 4,0 to 12,0 to appear strongly, with a resulting shift of the spectrum toward the blue and a deemphasis of the long wavelength bands such as 0,11, 1,12, and 1,13. Either the N_2O acts to deplete the lower levels of the X state, or it emphasizes population of the upper levels of the B state by acting as a third party in the sulfur atom combination. Since the $N_2O \rightarrow N_2 + O$ energy of dissociation is 1.68 ev, the effects are most likely attributed to free atomic oxygen.

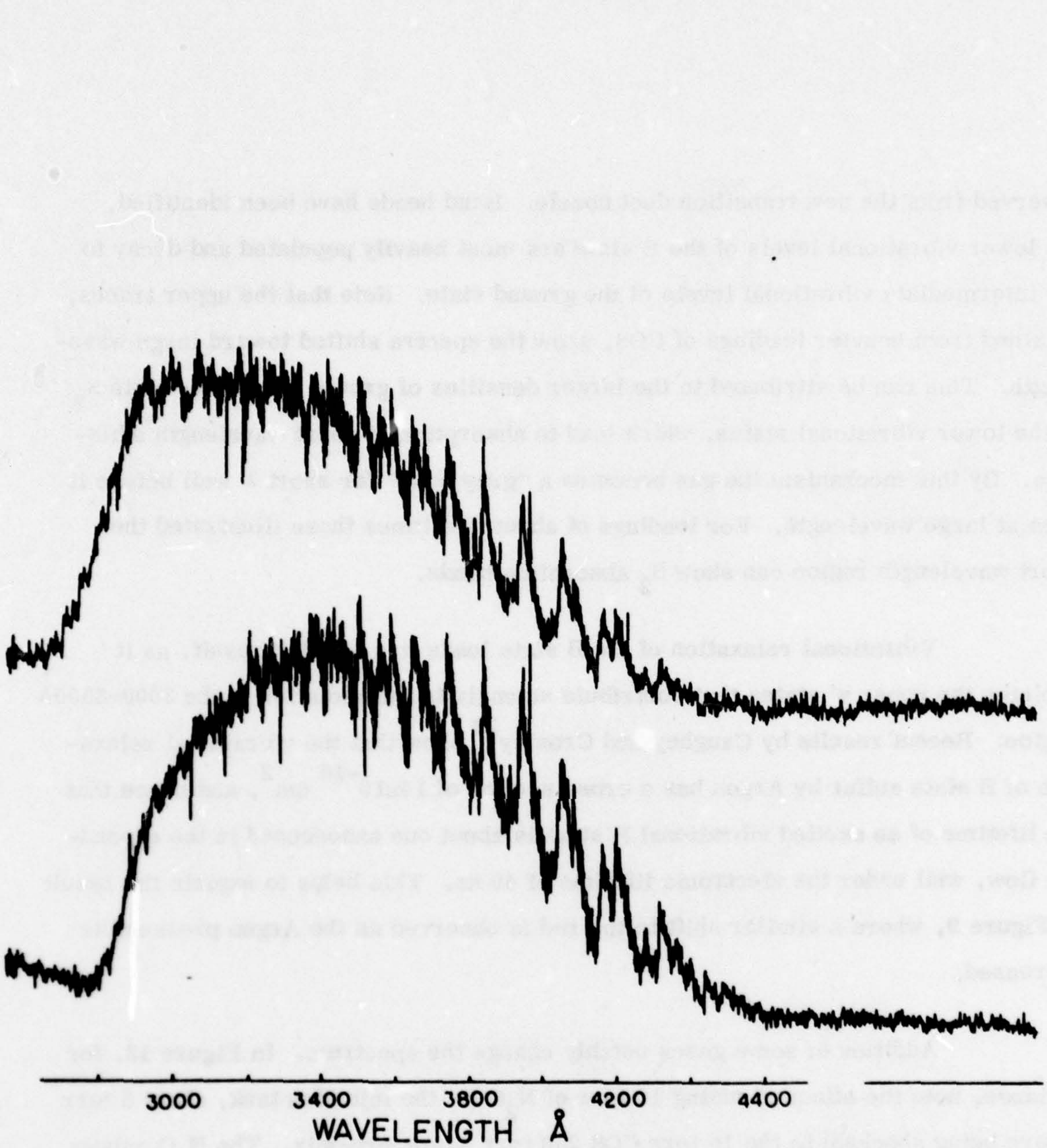


Figure 12. Comparison of spectrum of COS products in Argon (78021003-4) at bottom, with a similar shot but for $[N_2O] = [COS]$ causing spectral enhancement at small wavelength.

To investigate this further we did measurements with the following gases:

N_2 - Polaroid only, substituting nitrogen for Argon causes no large change in the form of the spectrum.

NO - Nitric oxide acts to depress the long wavelength side of the spectrum, does not emphasize the short wavelength transitions as much as N_2O.

O_2 - Oxygen causes a major shift of the spectrum to the UV, similar to that observed with the N_2O.

C. Theoretical Considerations

In this section we review theory and prior work that is immediately pertinent to S_2* radiation and lasing.

Bott and Jacobs[24] used a shock tube to dissociate SF_6 and H_2S and observed the recombination radiation. For fractional percentages of sulfur in the argon they observed the radiation was proportional to the square of the sulfur atom concentration, in support of the relation presented first in Section B. Based on this and in measurements by Fair and Thrush[25], one can represent the "light cycle" in the shock tube as

$$M + COS \rightarrow M + CO + S$$

and then

where the 2S obtained by S_2, S_2* dissociation is then again available for association. The two body inverse predissociation results in S_2* of v' = 10 and the three body association results in v' ≤ 9.

It is convenient to assume the COS dissociation occurs at the passage of the reflected shock wave. (By analogy with NO_2 dissociation[26], it appears the COS dissociation can be expected to consume 10 ns under typical conditions.) This releases the sulfur to atomic form. Considering the 3-body reaction as the main source of S_2* (Fair & Thrush argue that the lower levels of the B state cannot be populated only by relaxation of the v' = 10 state, with recent support from vibrational relaxation rates[27]) and using[25] $k_A = 2.8 \times 10^{-33}$ cm^6/sec for the conditions of Figure 12, we estimate the initial rate of formation of B state sulfur as

$$\frac{d[S_2{}^*]}{dt} = k_A [S]^2 [M] = 2.8\times10^{-33} (8\times10^{17})^2 (1.6\times10^{19})$$

$$= 2.9\times10^{22} \text{ molecules/cm}^3 \text{ sec}$$

In one microsecond, according to this, seven percent of the atomic sulfur is converted to S_2*. More exactly, one must include quenching, dissociation, and the natural decay of S_2*. Thus the relative amounts of S, S_2 and S_2* are given by

$$\frac{d[S_2{}^*]}{dt} = k_A [S]^2[Ar] - \frac{[S_2{}^*]}{\tau} - k_{Q_{S_2}} [S_2][S_2{}^*] - k_{Q_{Ar}} [Ar][S_2{}^*]$$
$$- k_D{}^* [Ar][S_2{}^*] - \bar{v}\frac{[S_2{}^*]}{n}\frac{dn}{dx} \qquad \text{(C-1)}$$

$$\frac{d[S_2]}{dt} = k_{Q_{S_2}} [S_2{}^*][S_2] + k_{Q_{Ar}} [Ar][S_2{}^*] + \frac{S_2{}^*}{\tau} - k_D [Ar][S_2]$$
$$- \bar{v}\frac{[S_2]}{n}\frac{dn}{dx} \qquad \text{(C-2)}$$

$$\frac{d[S]}{dt} = 2k_D [Ar][S_2] + 2k_D^* [Ar][S_2^*] - 2k_{Ar} [S]^2 [Ar] - v \frac{[S]}{n} \frac{dn}{dx} \qquad \text{(C-3)}$$

Implicit in the above are:

- S, S_2, S_2^* are dilute in an argon bath
- reactions due to the presence of CO are ignored, (CO is presumed to act inert as experiments have shown)
- S_2^* as well as S_2 is assumed to be susceptible to collisional dissociation

Rate constants for quenching have been recently measured[27]

$$k_{Q_{S_2}} = 1.3 \pm .3 \times 10^{-9} \ \text{cm}^3/\text{sec}$$

$$k_{Q_{Ar}} \cong 2 \times 10^{-12} \ \text{(implied, not explicitly stated in paper)}$$

The dissociation rate constants can generally be written as $Ae^{-\theta_D/\tau}$, where the exponential represents the energy dependence and A represents the collisional rate[22]. We find A by relating the S-S_2 equilibrium constant K_C to k_A and k_D[22]

$$K_C = \frac{[S]^2}{[S_2]} = k_D/k_A$$

Professor S. Bauer[29] has kindly furnished the results of equilibrium shock calculation, one of which pertains to a Mach 5 shock advancing into Ar/COS at respectively 130 and 7 torr COS. (This is similar to our case of P driver of 100 psi, 400 torr Argon and 20 torr of COS in the injection tank.) Some fifteen species are accounted for, including Ar, COS, S, S_2, CS and CO - but not S_2^*. We have taken his results

to calculate K_C, and by use of k_A and $\theta_D = 4.4$ ev = 51000°K to calculate k_D.

$$k_D = 1.14 \times 10^{-8} e^{-51000/T}$$

k_D* is more troublesome - as we know of no prior work including this type of term and any rules as to how to evaluate it. Setting $k_D^* = k_D$, or ignoring the term results in unreasonably high S_2^* densities. Specifically, by setting d/dt = 0 in equations C-1 through C-3 it is straightforward to solve for equilibrium densities of S, S_2 and S_2^*. For the run illustrated, Figure 12 lower, the dissociation of COS will quickly lead to initial densities of 8×10^{17}/cc of CO and S in an Argon bath of density 1.6×10^{19}/cc. Sulfur atoms recombine - with $k_D^* = k_D$ to give $[S_2] = 1.2 \times 10^{16}$, $[S_2^*] = 3.6 \times 10^{14}$ and $[S] = 7.7 \times 10^{17}$ @ T = 4500°K. Using the 36 ns lifetime for S_2^*, a cubic centimeter of the gas radiates 10^{22} photons/sec. This corresponds to a power level of 5 kW/cc, and a cooling rate of 10^7 °K/sec - both much higher than observed.

One might expect that these discrepancies can be resolved by considering that radiation as being trapped by absorption in the ground state diatomic sulfur. In equilibrium at 4500°K, each of the lower vibrational states has a population of $\sim 10^{15}$/cc, v'' = 12 population is about 10^{14} (computed using the above noted total for $[S_2]$ of 1.2×10^{16}). Rather than calculate the gas opacity, consider:

a) in very bright, high COS loading runs we see absorption bands (around 26-3300Å) in the spectra taken with the side flow configuration. We estimate the population of the absorbing S_2 (v''=3) state is about 4×10^{15}/cc, path length ~10 cm.

b) Leone[30] notes about 25% transmission of the pump laser with 1 torr pressure in the cell. This corresponds to $[S(v'-4)] \cong 10^{14}$.

These cases imply that the path length of radiation is 1-10 cm for the case of interest. By comparing the pressure profiles for the side mount nozzle and transition section geometries, both have 2-3 ms periods of sustained high pressure. There is no evidence of the fast radiation cooling that would be expected even if the radiation path were much less than a centimeter. Hence we conclude that radiation trapping is not significant, and that $[S_2*] \ll 10^{14}$.

We thus are led to propose that the dissociation of S_2* is the dominant term, larger than either natural decay or quenching in the high temperature-density region behind the reflected shock. We suggest the collision of an Argon atom with an excited sulfur molecule leads to a collision induced transition from the $^3\Sigma$ state to the $^3\pi$ and dissociation to two ^3P sulfur atoms. Using the same collisional factor A as in k_D, but changing θ_D from 51000°K to 5220°K (for 0.45 ev)

$$k_D* = 1.14 \times 10^{-8}\ e^{-5220/T}$$

The resulting ratio of $[S_2*]/[S_2]$ is greatly reduced in equilibrium:

T	[S]	$[S_2]$	$[S_2*]$
4500°K	8×10^{17}/cc	1.4×10^{13}	5×10^{11}
4000°K	8×10^{17}	6.1×10^{13}	5.4×10^{11}
3000°K	7.9×10^{17}	5.8×10^{15}	6.7×10^{11}
2600°K	4.6×10^{17}	1.7×10^{17}	4×10^{11}
2000°K	0.18×10^{17}	3.9×10^{17}	0.01×10^{11}

These levels of S_2* emit about 5 watts/cc, which is more consistent with our results. The absolute light emission measured by Bott & Jacobs[24] at T = 3000°K corresponds to some ten watts/cc in a 0.1 micron band.

The last term in each of Equations C-1 through C-3 accounts for the expansion of the gases as they flow through the nozzle, v is a convective flow velocity and n is a density - the Argon density serves well here.

Approximate solution of these equations with given profile of T(x) - for flow through the 2mm slit - suggests the chemistry significantly lags the flow and hence the S_2* at a near downstream position is well above the equilibrium value.

A step-by-step numerical calculation was attempted but is difficult due identical terms. Solution @ 1 mm downstream of a 2 mm slit with T_o = 5000°K and initial COS density of $8x10^{17}$/cc shows $[S_2*] = 1.9x10^{11}$/cc with $[S_2] \cong 4x10^{15}$/cc.

D. Gain Measurements using Sulfur

The early gain and lasing measurements were made using the side mount nozzle, the new transition duct was designed to allow further measurements under more controlled conditions.

The 0,6 transition of S_2, at 3665Å, was first examined using a pair of mirrors coated for 340-370 nm (one maximum reflection, one one-percent transmission). With run 77110301 we started measurements at 4790Å, characteristic of the 3,18 band using broadband mirrors coated for 450-650 nm. To account for beam curvature due to dn/dx of the nozzle flow (Appendix C), the mirrors were first tuned to resonance using a He-Ne laser beam, then detuned by an angle appropriate for the resonance with the flow banding the cavity beam. The Glan-Thompson prism was used to divide the light transmitted through the 1% transmitting mirrors into $\parallel$ and $\perp$ components and each were monitored with a monochrometer of bandwidth ~3 nm set to the wavelength of interest (such as 4790Å). An aperture placed before the prism and the limited slit size (typically 1/2 mm x 2 mm high) provided angular

collimation of the light. The enhancement of the $\parallel/\perp$ ratio was as high as 4.5, this was observed for the 1,12 band at 4200Å. Measured bending of the cavity beam due to flow gradients was five milliradians.

We conclude there is no gain due to sulfur association, rather that there is apparent absorption at v" = 6, 18 and 12.

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20. R. J. Donovan, L. J. Kirsch and D. Husain,

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23. T. A. Caughey and D. R. Crosley, "Collision-Induced Energy Transfer in the B $^3\Sigma_u^-$ state of Diatomic Sulfur", personal communication (1978).

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26. H. Hiraoka and R. Hardwick, "Emission and Dissociation of NO_2 in Shock Waves", J. Chem Phys 39, 2361 (1963).

27. T. A. Caughey & D. R. Crosley, "Collision-Induced Energy Transfer in the B $^3\Sigma_u^-$ State of Diatomic Sulphur", personal communication (1978). (See also comment on pg. 469 of ref. 28.)

28. T. A. Caughey and D. R. Crosley, "Coherence retention during rotationally inelastic collisions of selectively excited diatomic sulphur", Chem. Phys. 20, 467 (1977).

29. Prof. S. H. Bauer, Cornell University Department of Chemistry, personal communication. Under a separate program, Prof. Bauer studied IR laser initiated reactions leading to B state S_2 and the resulting B-X radiation.

30. S. Leone, personal communication (August 3, 1978).

APPENDIX A

DESCRIPTION OF THE SHOCK TUBE FACILITY

1. THE TUBE WITH POWDER INJECTION

The laser experiments described in the text require a flow of metal vapor to be reacted to give chemiluminescence. For some materials the required temperatures are very high; furthermore, many high temperature metals are very reactive. Hence it is convenient to use a shock tube to vaporize the metal, the temperatures are easily attained and the wall boundary layer protects the apparatus from notable reaction with the hot gas.

The chemical species that can be studied with a conventional shock tube are limited to those that are gaseous (vapor) at room temperature. Therefore many compounds energetically of interest for visible chemical lasing cannot be studied conveniently using standard shock tube techniques. The two-phase (gas-powder) shock tube overcomes this difficulty, and includes the solid materials among those whose chemical and optical properties can be analyzed by vaporizing in a shock tube.

Powder injection shock tube techniques were developed several years ago by Xonics personnel under ARPA sponsorship to study the optical physics of ablative materials. We have adapted that shock tube for the present purposes.

Figure A-1 shows the laboratory layout of the powder-shock tube facility as modified for the present work. The basic dimensions of the shock tube are as follows:

Inside diameter	78 mm (3 in)
Test section length	13.28 m
Combustion driver chamber length	0.92 m

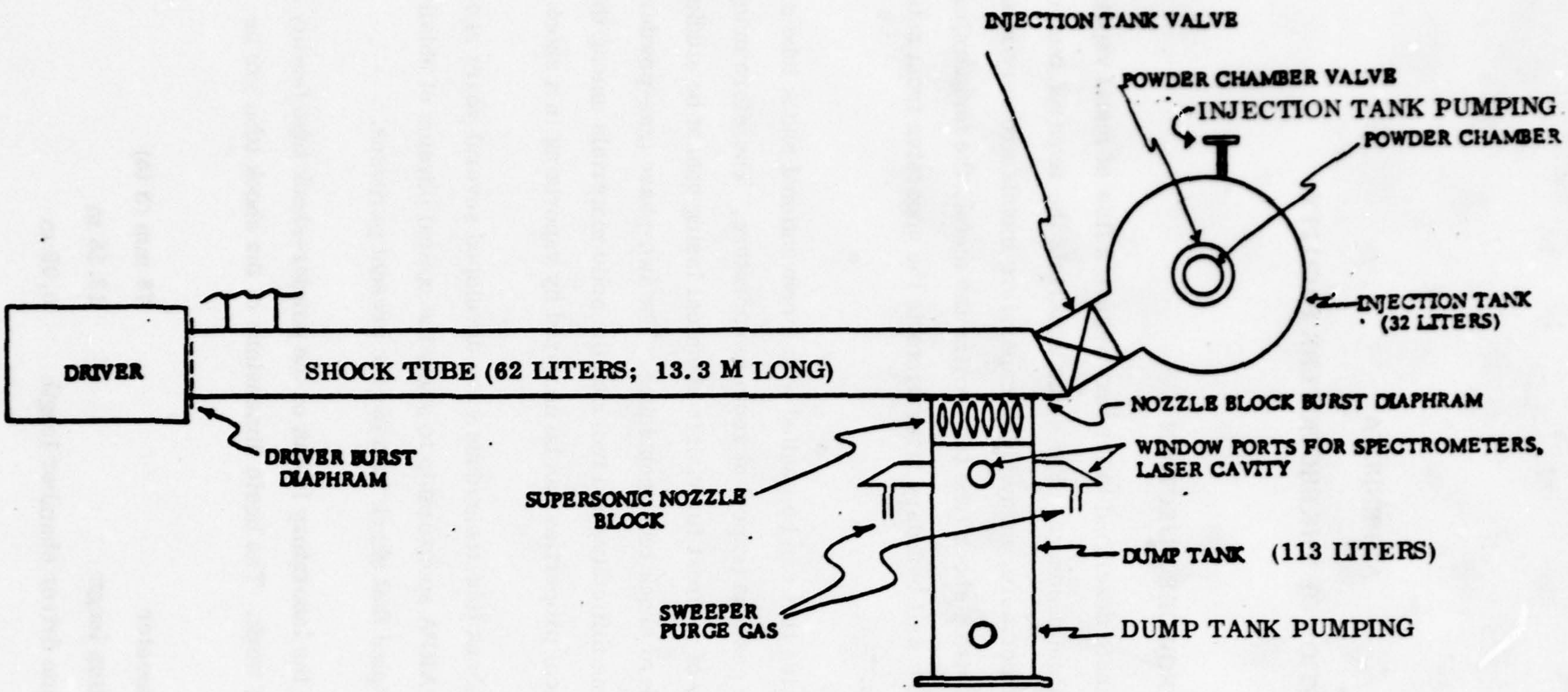


Figure A-1. Schematic diagram of powder injection shock tunnel system.

Test section volume	62 liters
Injection tank volume	32 liters
Powder chamber volume	43 ml

In the preparation for an experimental run we typically pressurize the powder chamber to 500 psi and the injection tank to 200 torr. Since the test section pressure

$$P_1 = \frac{0.043\ P_{pc} + 32\ P_{it}}{96} = \frac{111 + 6400}{96} = 78.25$$

the pressure P_1 is typically 80 torr. P_1 and other shock tube parameters are illustrated in Figure A-2. Figures A-3 show the Injection-Dump Tank region.

a. <u>The Driver</u>

The combustion driver is stressed for pressures to 10,000 psi to accommodate an optimum charge of $He/H_2/O_2$ mixture for maximum sound-speed generation. The operating range of the shock tube in terms of equilibrium temperature behind the incident shock wave (with Argon as the driven gas) ranges to well above 10,000°K. This temperature and specific enthalpy range is more than adequate for vaporization of even the most refractory materials, including tungsten and carbon.

The driver is loaded for each shot with a mixture of $He/H_2/O_2$ (70:20:10) and the mixture is ignited by exploding a wire stretched along the centerline. As the heat of formation of gaseous H_2O is 57.8 kcal/mole, the temperature rise can be estimated by the perfect gas relation:

$$7\ C_{v_{He}}\ \Delta T + 2\ C_{v_{H_2O}}\ \Delta T = 2(57,800)\ \text{cal.}$$

For $\gamma_{H_2O} = 4/3$ and $\gamma_{He} = 5/3$, $\Delta T = 3540°$, and thus $T_4 \cong 3840°K$. (See Figure A-2

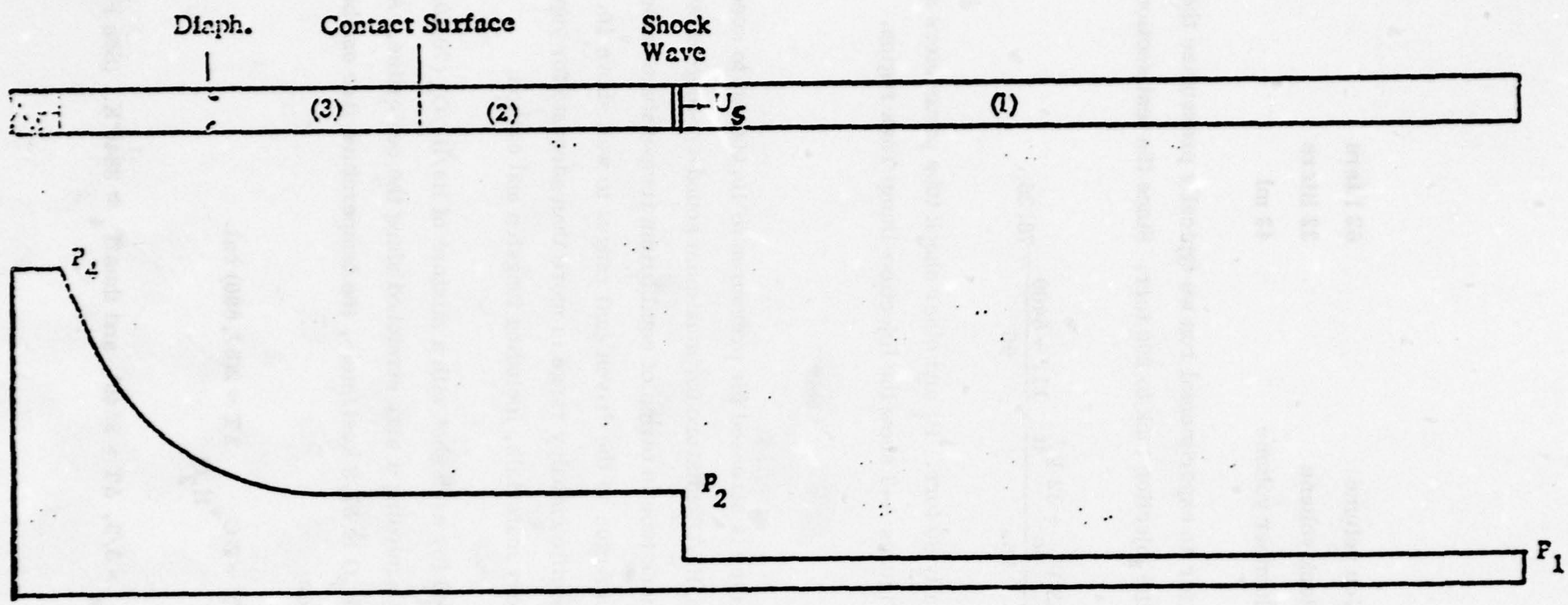


Figure A-2. Motion of shock tube gas just after the diaphragm burst. Before bursting, gas 4 was all at P_4, gas 1 at P_1. The shock compresses gas 1 to pressure P_2, while gas 4 expands to $P_3 = P_2$.

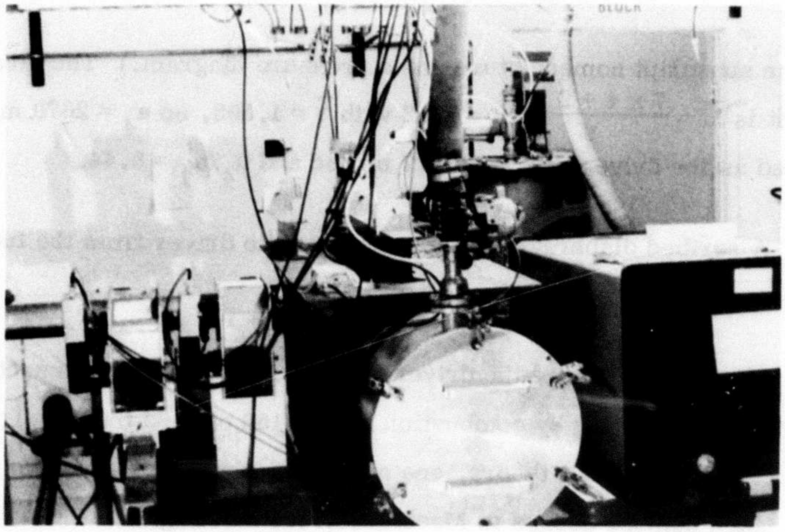


Figure A-3a. Photo of the test end of the shock tube with side mount nozzle. Monochrometers are at left, the dump tank at center and the spectrograph is at right. Instrumentation cables lead up to ceiling hung trays (above photo) which carry them out of the test cell to the signal recording by 3-4 oscilloscopes in a separate area. The injection tank is seen right rear. Flexible vacuum hoses allow the wheel mounted dump and injection tanks to be moved to change nozzle diaphragm and for cleaning.

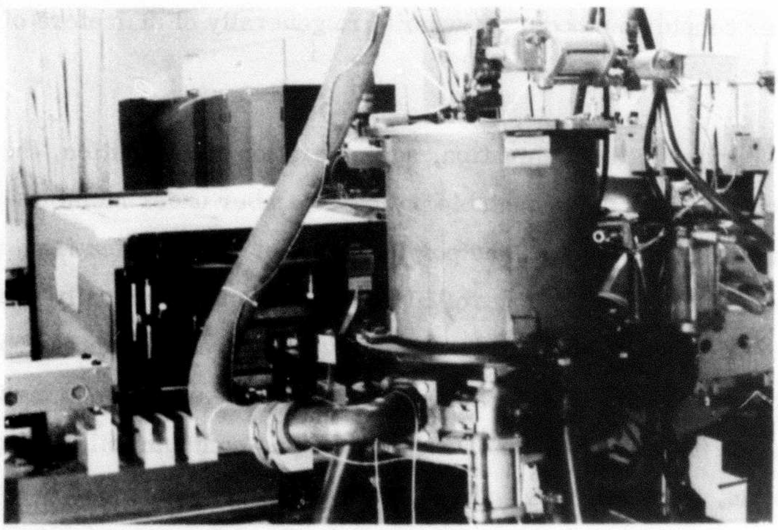


Figure A-3b. Photo from the opposite side, with the injection tank in foreground, Spex and alignment laser at left.

for the subscript nomenclature and a pressure diagram.) The mean molecular weight is $\bar{M} = \frac{7 \times 4 + 2 \times 18}{9} = 7.12$ with $\bar{\gamma} = 1.595$, so $a_4 = 2670$ m/sec. As Argon is used as the driven gas, $a_1 = 317$ m/sec and $a_4/a_1 = 8.44$.

A scribed diaphragm which separates the driver from the tube bursts due to the pressure rise.

Typically, we load the driver to 100 psia and the driven section to 80 torr. Following the heating by combustion $P_4 \cong 1150$ psi and thus $P_4/P_1 \cong 700$. Using perfect gas shock tube theory, one predicts a shock Mach number of 9. The measured Mach number decays to Mach 5-6 at the test region. This discrepancy is due to boundary layer effects as discussed later.

b. The Powder Injection System

Metal and metal-halide powders were purchased commercially, and in some cases the sizes were graded using a vortex-type separator. Size and shape measurements were made by optical microscope, scanning electron microscopy, and by Coulter counter methods. Powders are generally of diameters of less than ten microns.

To prevent contamination, agglomeration and oxidation, the powder is stored and loaded into the demountable powder chamber under moisture-free conditions in an Argon-filled drybox. The powder chamber is separated from the injection tank by a small electrically-controlled valve. Larger electrically-controlled valves separate the injection tank and the dummy volume from the shock tube. The supersonic nozzle block (a 20-cm long array of small nozzles) and dump tank are isolated from the shock tube prior to the shock wave by an aluminum foil diaphragm. Before injection, the shock tube, dump tank and dummy volume are evacuated, the injection tank is pressurized to several torr, and the powder chamber is pressurized to 500 psig. The valve between the dummy volume and the shock tube is initially open,

with the other valves closed. Upon initiation of an electronically-timed automatic firing sequence, the powder chamber valve is opened and the powder is blown violently into the injection tank. One second later, following mixing of the powder with the gas in the tank, the valve connecting the injection tank with the shock tube is opened and the contents of the injection tank rush into the driven section of the shock tube and into the dummy volume tank. The injection tank valve and the dummy volume valve are closed immediately after injection, and thereafter the shock tube is fired.

The incident shock wave accelerates the metal particle-argon mixture and the temperature jump initiates vaporization of the metal. The reflected shock from the end wall stops the flow. To ensure complete vaporization, the time required must be small compared to the flow duration period of approximately 1 millisecond.

For one micron size particles, the particle vaporization is calculated to occur in under 10 microseconds. Laser beam attenuation measurements support this estimate.

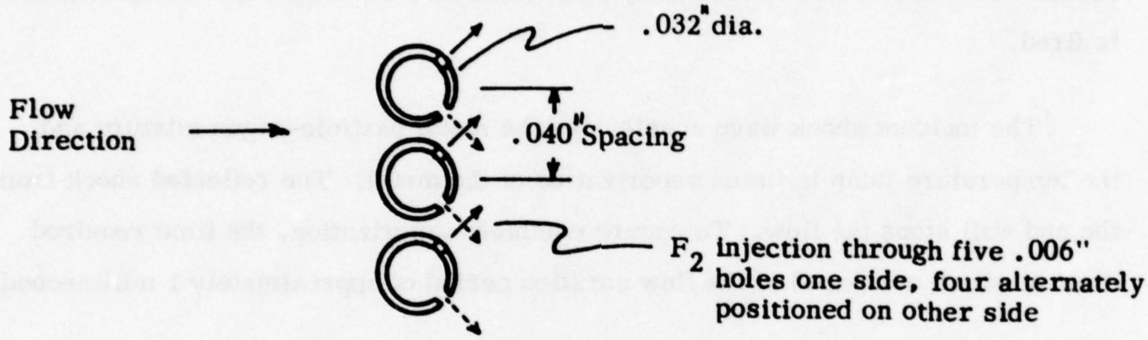
The atomic absorption method has been used to measure the metal atom density in the flow. A loading of 200 mg of copper provides results in a copper atom density in the flow region downstream of the nozzle array of 10^{15}/cc (if no oxidant has been injected). Atomic densities can be well above 10^{16}/cc for higher loadings but these high densities are beyond the measurement range by these absorption techniques.

c. Nozzles and Dump Tank

Multitube injector nozzles - designs "2" and "4" were used for Powder/Oxidant and excimer tests.

Nozzle 2

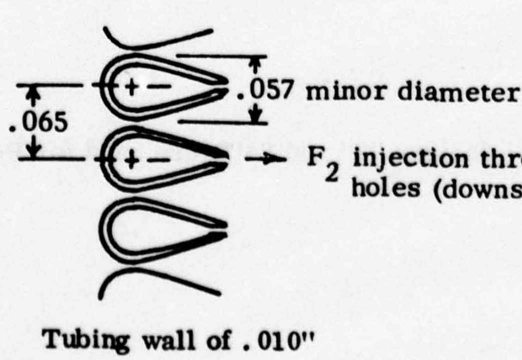
Nozzle 2 is a major departure in nozzle design, as it uses only a wall of tubes spaced by .008" for nozzles, and these same tubes are the fluorine injectors. For simplicity in manufacture, the injector holes are at ±45° to the flow direction.



In all, there are 175 such tubes, each of 1/4" length, making a flow field of 1/4" x 7" length.

Nozzle 4

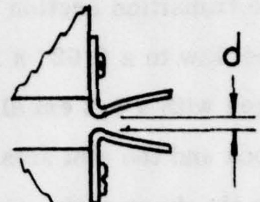
Nozzle 4 uses drawn tubing so as to provide a supersonic nozzle contour with the result of reduced static temperature due to high exit Mach number.



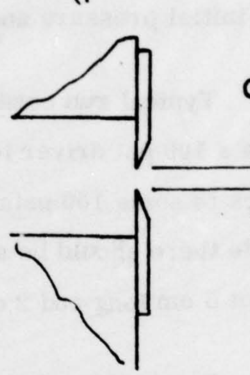
Non-Injecting Nozzles

For use, as in the sulphur studies, where oxidant injection was not required, the following forms of nozzles were used:

i) Contoured 2-d nozzle, made from 1.5 mm steel sheet. The spacing d was variable by loosening five screws, the maximum divergence angle was 20°.



ii) Slit nozzle - made of two feathered plates of sheet steel, d was adjusted to 2 mm. Used both as side mount nozzles and with the transition duct.



Dump Tank

As noted before, the nozzle and the dump tank are physically separated from the shock tube by a thin aluminum diaphragm which is broken by the (~ 80 psi) pressure of the reflected shock. Prior to the shot the dump tank is pumped down to a few micron pressure, so that the flow from the nozzle expands into it as into a vacuum. The dump tank is 1.6 meters long, and thus about 10 ms delay elapses between the start of the flow and the arrival at the nozzle of the wave reflected from the far end of the tank. During that period, the flow can be thought of as a free expansion into a large region of very low and undisturbed pressure.

Flow gradients in the expansion region can affect the optical properties in the laser cavity. These effects are discussed in Appendix C.

2. THE TUBE WITH TRANSITION DUCT

A photograph of the transition duct and dump tank is given as Figure A-4. The transition section was designed to transform the 3" circular cross section shock tube flow to a 0.62" x 12" rectangular section, which is blocked by a pair of knife edges with a 0.2 cm slot (see Figure A-5). The knife edges reflect the incident shock and the slot acts as a nozzle through which the hot gas can flow to expand into the dump tank. Generally, this configuration uses no diaphragm and hence the initial pressure and gas mix are identical in the driven tube and the dump tank.

Typical run conditions are initial pressure P_1 of 80 torr of 99% argon, 1% COS with a 100 psi driver loading. Behind the reflected shock of $M \cong 5$ the pressure rises to some 100 psia. Using Figures 5 and 6 of Bier and Schmidt (A-1) we conclude there should be a supersonic region expanding from the slot aft into the tank about 5 cm long and 2 cm high (i.e., ±1 cm from center plane).

Due to the relative simplicity of the flow, the transition section is preferred for studies where powders are not required and time from shock to expansion should be short. It was used for the final measurements using COS to produce S_2*.

3. LASER MIRRORS

Dielectric coated laser mirrors were made by Valtec to our specification. Transmission curves for a typical pair of mirrors are given in Figure A-6.

A-1) K. Bier u. B. Schmidt, "Zur Form der Verdichtungsstosse in frei expandierender Gasstrahlen", Z. fur ang. Physik, 13, Nov 1961, p. 34.

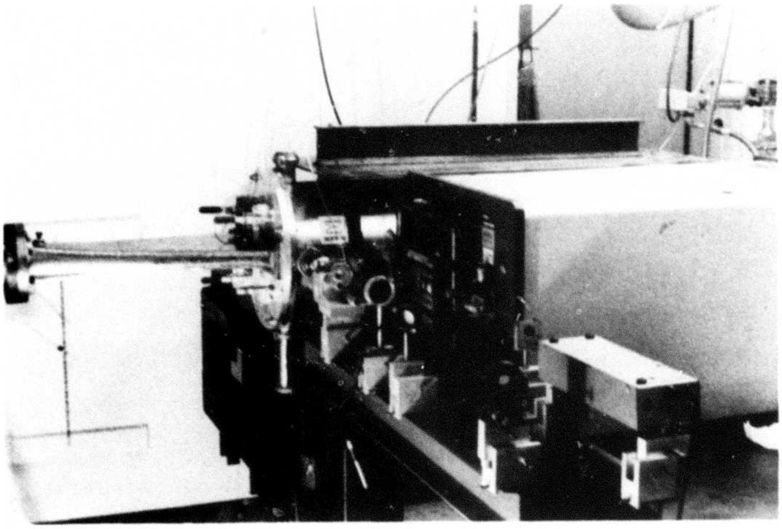


Figure A-4. Photo of the transition duct - dump tank as used with COS. Alignment laser and the Spex spectrograph are in foreground, the monochron-ometers are hidden behind the dump tank. (At the time the photo was made, the Kistler location at the start of the transition was plugged by a bolt.)

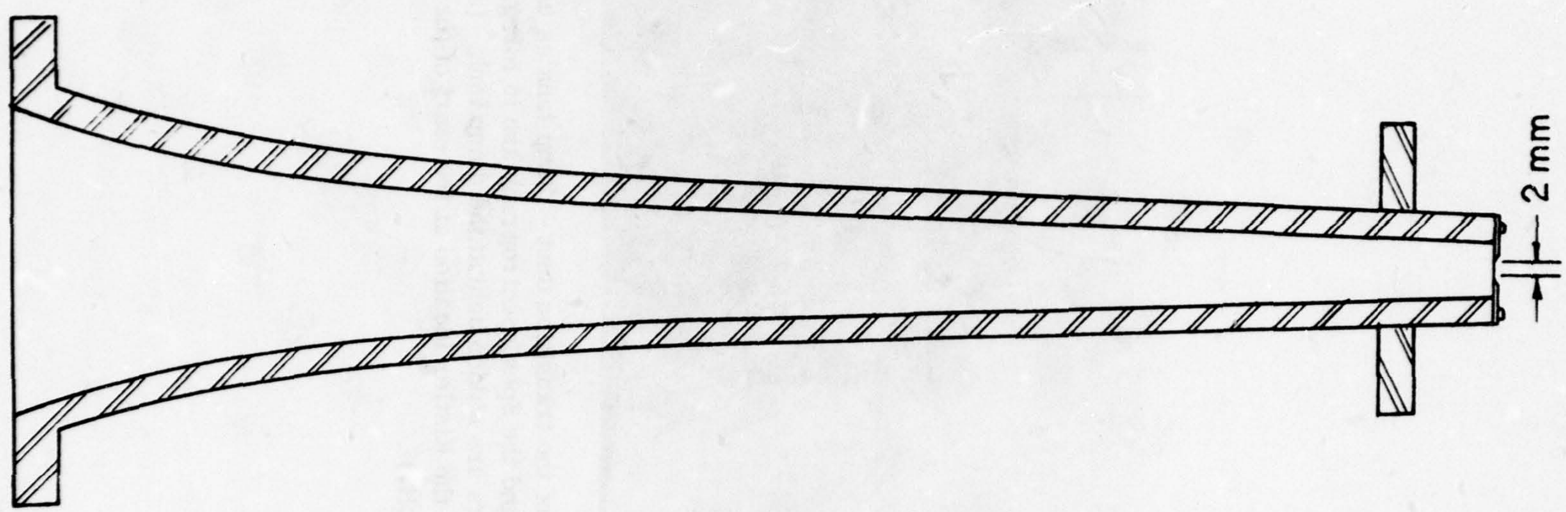


Figure A-5. Schematic cross section of the transition duct (not to scale). The duct is of 3" diameter at left, and 0.62 x 12" at right. As the side pieces are straight and diverging, the top and bottom are contoured to hold constant area over the length. A pair of stainless steel knife edges cover the end but for a 2mm wide slot which serves as a slit nozzle.

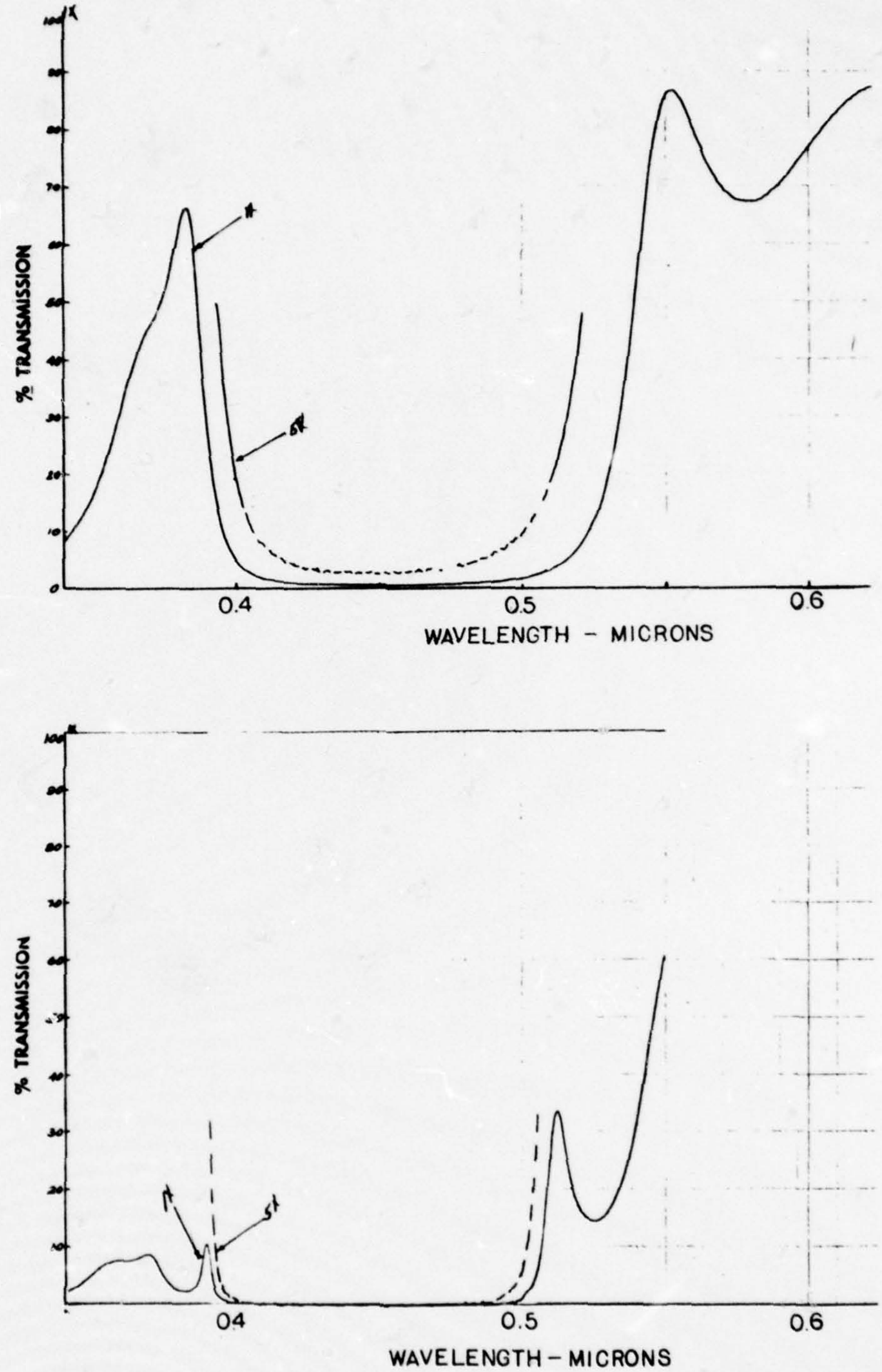


Figure A-6. Typical mirror characteristics. Two curves are shown for each mirror corresponding for the lower curve to the labeled 0–100% T scale and for the upper, abbreviated, curve to 0–20% T.

APPENDIX B

GAIN MEASUREMENT BY POLARIZATION ANALYSIS

Where laser gain is expected to occur on a line that is spectroscopically observable, one can use the spontaneous emission itself as the probe for an equivalent gain measurement. If the active medium to be tested is enclosed in a low loss optical cavity as shown in Figure B-1, in which surfaces at Brewsters angle are employed to minimize reflective losses, one polarization of the emission will be reflected back and forth in the cavity with little loss while the complementary component will suffer a 30% loss at each Brewster window. A portion of the cavity power can be transmitted at one mirror, say of 1% transmission, and analyzed for the relative content of each polarization. This is accomplished by use of a *Thompson prism (Lambrecht SBTA-12-45) which separates the two components of* polarization. The relative content of each polarization will vary with α the gain coefficient of the medium in the cavity. When the emission occurs from essentially a black body source (highly absorptive $-\alpha L >> 1$) there is no effect of the cavity and both polarizations of radiation are emitted equally, whereas with gain a damped standing wave exists for one polarization in the cavity and therefore emission is stimulated faster for the favored component than for its complement. As threshold is attained, the polarization of the emitted light approaches 100%.

We proceed by deriving the equations which represent this. The gain medium itself is of length L with absorption coefficient α. Each Brewster window has transmission 1-S, where (by Born & Wolf notation[1]) for the polarization parallel to the plane of incidence $S_{\parallel}$ approaches zero - limited only by surface imperfections and dust - and $S_{\perp}$ is near 0.3. Dielectric coated mirrors of R + T = 1 are assumed, where T is the power transmissivity and R the reflectivity. The average gain per pass (1/2 "round trips") is

$$G = (1-S)^2 \sqrt{R_1 R_2}\, e^{-\alpha L} - 1$$

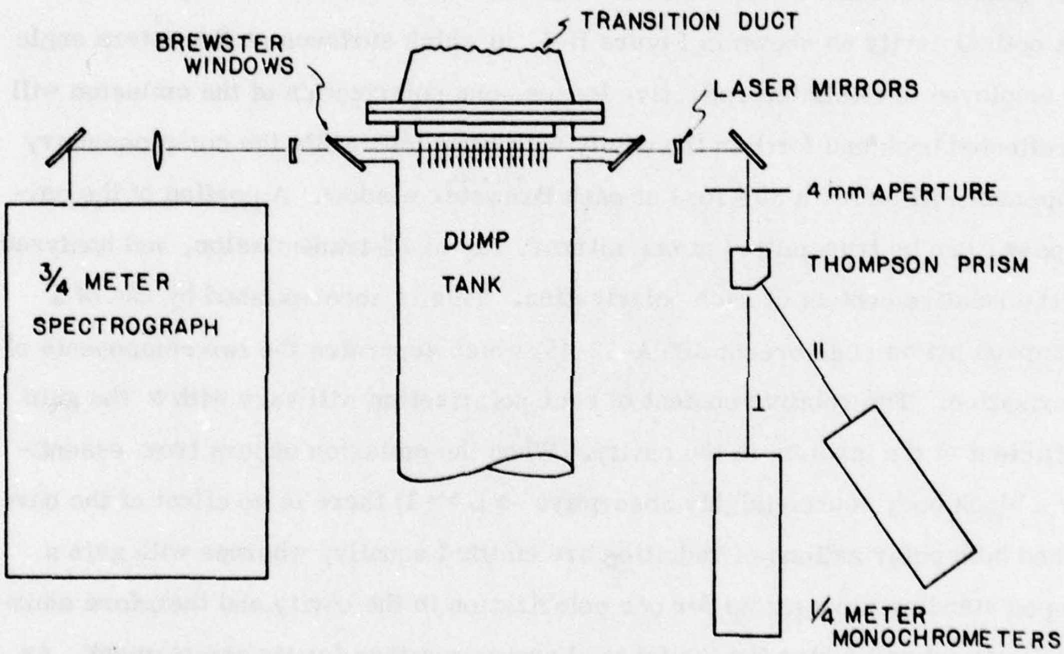


Figure B-1. Schematic of apparatus used for laser gain measurements. The total path length from the center of the nozzle to the monochrometers was 1.2 meters.

with R_1 and R_2 representing the two mirrors of generally different reflectivity. For spontaneous emission of intensity I_S, $I^b = I_S\, T\,(1-S)$ is transmitted through the output mirror with the other mirror blocked.

With both mirrors on, one must account for the gain and loss per pass to find the resultant electric field. The magnitude of the electric field vector at the exit mirror due to spontaneous emission is $A_S(1-S)^{1/2}$ and the reflected field is $-\,r\,A_S(1-S)^{1/2}$. After a trip to the opposite mirror and back this vector is increased by gain and decreased by finite reflectivity and window transmission, and such repeated "trips" add to the output intensity. The optical field set up by spontaneous emission will be broadband and incoherent. (For large gain and coherence, one must count the additive electric fields to calculate the sum field at the exit mirror.) Thus if light of intensity $I_S(1-S)$ is partially reflected between the output mirror and an unblocked opposing cavity mirror the output becomes the sum

$$I = I_S(1-S)\, T\, \{ 1 + R^2(1-S)^2 e^{-2\alpha L} + R^4(1-S)^4 e^{-4\alpha L} + \ldots$$

$$+ R\,(1-S)^3 e^{-\alpha L} + R^3(1-S)^5 e^{-3\alpha L} + \ldots \}$$

$$= I_S(1-S)\, T\, \frac{1 + R(1-S)^3\, e^{-\alpha L}}{1 - R^2(1-S)^2\, e^{-2\alpha L}}$$

Comparing this intensity to I^b, the output intensity with the blocked mirror

$$\frac{I}{I^b} = \frac{1 + R(1-S)^3\, e^{-\alpha L}}{1 - R^2(1-S)^2\, e^{-2\alpha L}}$$

Typical values are, for R = .99:

αL	S = 0	S = 0.01	S = 0.3
0.1 (loss)	9.60	8.75	2.15
0.01	50	33.4	2.52
0	100	50	2.58
-0.01 (gain)	2×10^4	99	2.63
-0.1	---	∞@ ~ .02	3.33

The last column is typical of the $\perp$ polarization, the next to last (S = .01) may be expected *for the* $\parallel$ *polarization.* Defining R as the ratio of the $\parallel$ intensity as divided by the $\perp$ intensity

αL	R
0.1	4.1
0.01	13.3
0	19.4
-0.01	37.6

The highest ratios we observed, with the excimer flows, were on the order of twenty. More commonly it was difficult to achieve a ratio as high as ten.

In an attempt to learn more of this method we used a 30-cm long tube with Brewster windows, a flowing helium-neon mix, DC excited, and with mirrors appropriate to lasing at 6328Å. We observed both polarizations of the output with 1/4 meter monochrometers. By operating off optimum conditions we could vary the gain up to the point of lasing. The mirrors were measured to be 0.5% transmission. Using all care, we were not able to exceed R of 20 without encountering lasing (as the $\parallel$ polarization would rapidly increase in intensity).

We consider more bench tests of this type, using more closely controlled parameters, as being important to use of polarization analyses as a quantitative means of gain analysis.

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1. M. Born and E. Wolf, Principles of Optics, Pergamon Press (1965).

APPENDIX C

FLOW EFFECTS ON OPTICAL CAVITY

We have previously reported the use of a helium-neon laser beam to monitor the particulate density in the nozzle flow. We noted that unvaporized metal powder produced only a transient attenuation.

More recently, we have noted that the optical path is affected even with no particulates present. We can explain these results in terms of the density variations in the flow and of the refraction index variation due to density variability.

The speed of light in a transparent medium is related to the universal constant c by v = c/R, where the refractive index is characteristic of the gas and its difference from unity is proportional to pressure.

gas	n at one atmosphere (Handbook of Chem. Phys.)
Argon	1.000281
Nitrogen	1.000295 - 1.000300
Nitrous Oxide	1.00051

SLIT NOZZLE

Consider the slit used for the S_2* experiments, with width d = 2 mm. The flow expands through this slit from the high density inside the shock tube to the low density of the dump tank, as illustrated in Figure C-1. Near the slit the density gradient $d\rho/dx$ is high, causing dn/dx which "bends" the optical path.

The amount of this effect was measured using a He-Ne laser beam and a United Detector Technology position sensing photodiode, as illustrated in Figure C-2.

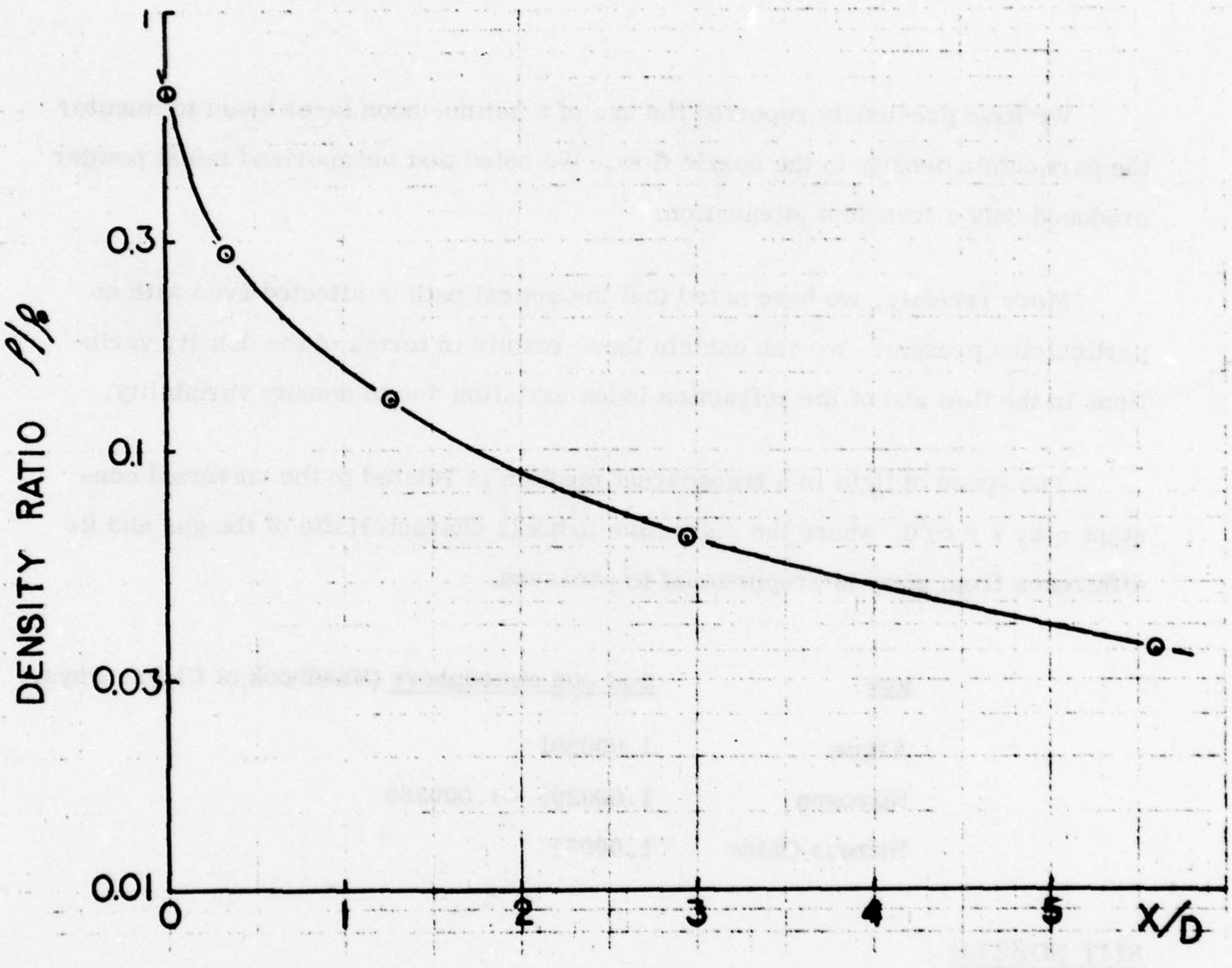


Figure C-1. **Axial density profile for slit flow. This relation is estimated by consideration of the "Schlitz duse" results of Bier & Schmidt[2], use of the $\cos^2\theta$ law known to be valid for orifice flow[3] and the isentropic Mach number/Area/density relations[4].**

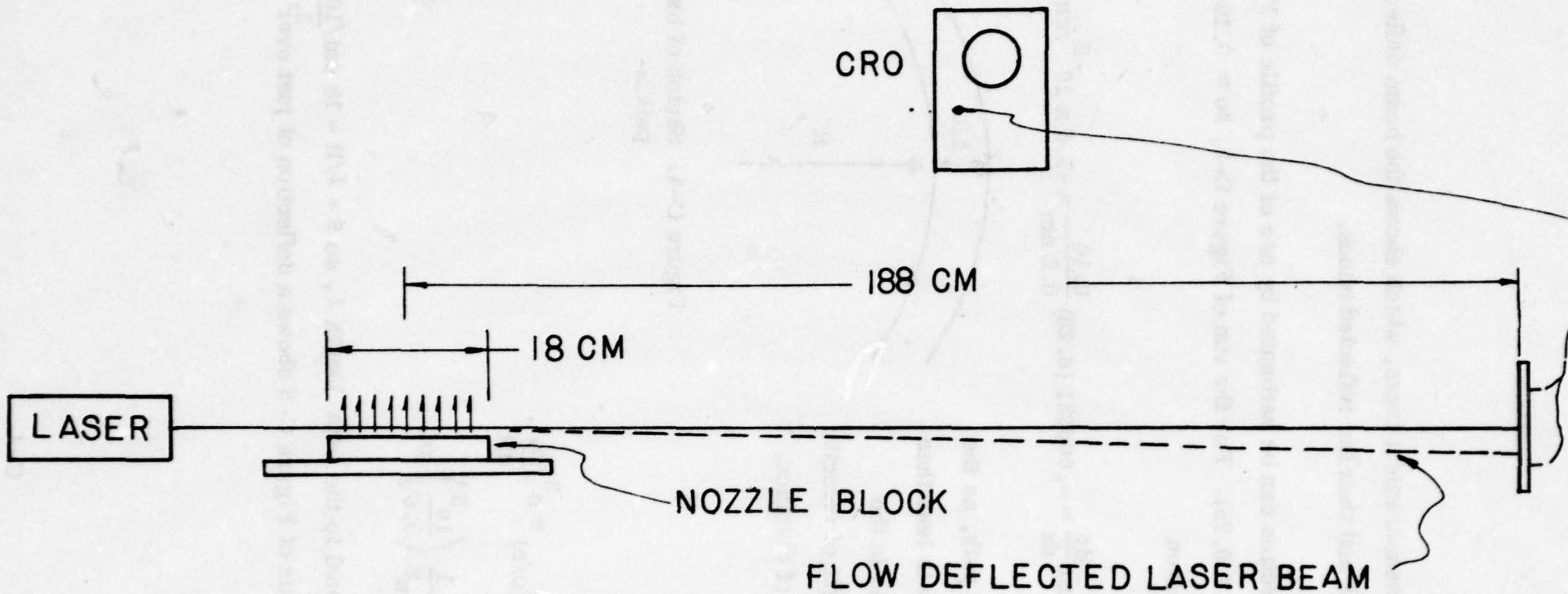


Figure C-2. Schematic of apparatus for measuring optical path deflection due to flow gradients. Deflections as high as a centimeter have been observed from the slit nozzle.

Figure C-3 shows a typical measurement trace, which shows the beam deflections due to first the incident shock and then the reflected shock.

The amount of the deflection can be estimated by use of the profile of Figure C-1 (at x = 1 mm, $\frac{D}{\rho o}\, d\rho/dx \cong 0.25$). For the run of Figure C-3, $\rho o \cong 0.16$ of atmospheric (STP), so for Argon

$$\frac{dn}{dx} = .000281\,\frac{d\rho}{dx} = -.000281\,(0.25)\,\frac{0.16}{0.2\text{ cm}} = -5.6 \times 10^{-5}/\text{cm}.$$

This gradient bends the light path, as the light velocity near the nozzle is less than that at a further distance. As in the sketch of Figure C-4, the light of velocity v + Δv goes an extra portion of distance,

$$\frac{\Delta v}{v} = \frac{\Delta R}{R}\ .$$

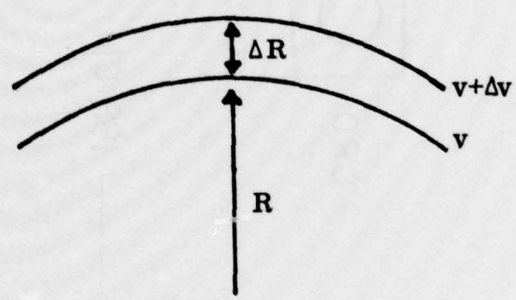


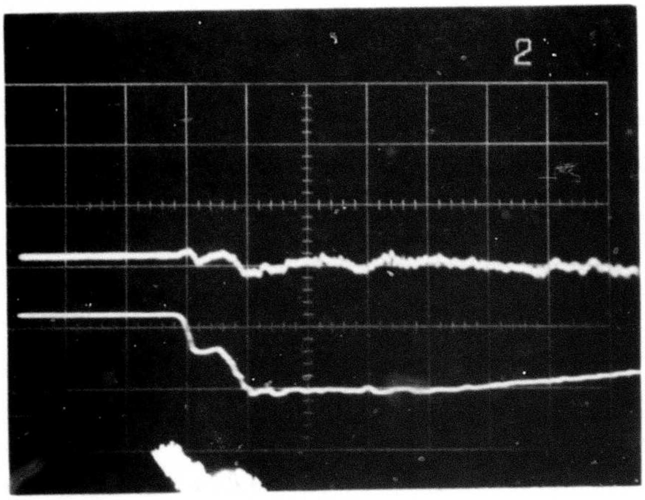
Figure C-4. Sketch of bent light path.

Thus

$$R = v/(dv/dR) \cong c/\frac{d}{dR}(c/n) = n^2/\frac{dn}{dR}\ .$$

Using dn/dx for dn/dR; $R^{-1} = \frac{1}{n^2}\left(\frac{10^5}{5.6}\right)$ m.

The deflection θ is proportional to the path length ℓ, so $\theta = \ell/R = 18\text{ cm}/\frac{10^5}{5.6} = 1.0 \times 10^{-3}$ radians. The run of Figure C-3 shows a deflection of just over a milliradian.



0.5 ms/cm

Figure C-3. Oscillograph of vertical (at center) and horizontal deflection (bottom) of a helium-neon laser beam due to flow through a slit nozzle of 2mm width. The beam is approximately 1mm downstream of the slit plane. Deflection of 1 cm ≅ 1 milli-radian. 50 psi driver and 6 torr of COS. Run 77103102.

EFFECT OF TURBULENT FLOW

The trace of Figure C-3 also shows some random fluctuation of the beam position. One might wish to ascribe these to turbulent fluctuations in the flow. In the case of our nozzles numbered two and five, made of multiple cylindrical tubes with holes in each tube for oxident injection, we might expect the turbulent fluctuations to be more important than the beam curvature due to the mean flow field gradients.

That turbulence is possible in even the very small scale flows characteristic of these nozzles is evident from consideration of the Reynolds number $Re \equiv \frac{vD}{\nu}$, where for a single tube d = 0.1 cm, $v \cong 10^5$ cm/sec and $v \cong 1\ cm^2/sec$, so $Re \cong 10^4$. A single cylinder at this Reynolds number will shed the Karman vortex street (ref. C-5, chapter 13). Closely adjacent cylinders, such as ours, greatly accelerate the flow through the passage, and we expect the interacting vortex streets to form turbulence. The injected oxidizer will add to the turbulence.

To estimate the beam propagation we refer to Chernov[6]. He assumes the index of refraction to deviate only slightly from a mean value

$$n(x,y,z) = n_o + \mu(x,y,z) \qquad |\mu| << n_o$$

where n_o is unity in Chernov's treatment, but it is convenient to use $n_o \cong 1$).

The fluctuations in n are assumed a random process in space and time, with correlation function

$$N_{12} = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} \mu(x_1,y_1,z_1,t)\ \mu(x_2,y_2,z_2,t)\ dt\ .$$

A correlation coefficient N is defined as

$$N = N_{12} \sqrt{\mu^2}$$

where μ^2 is the mean square fluctuation. Both N_{12} and N depend only on the coordinate differences. N(r) is modeled by

$$N(r) = e^{-r^2/a^2}$$

where a is called the correlation distance. We have no measure of a but a value of 1mm or less is expected. Proceeding to evaluate the mean square deviation of a ray after going a distance S, the "ray diffusion coefficient" D is defined as (Chernov's Eq. 35)

$$D = \sqrt{\pi}\ \frac{\overline{\mu^2}}{a} .$$

For present cases, with driver pressure of 100 psi, $D \cong 2x10^{-7}$/cm. With oxidizer injection $D \cong 10^{-6}$/cm is expected.

Chernov finds the mean square deviation angle to be (Eq. 51)

$$\theta^2 = 4\ DS$$

which for our case (S = 18 cm) results in θ_{rms} = 4 milliradians, or more with injection of oxidizer. Note that the amount of the rms deviation is proportional to the flow density.

Measurement of the deflection (runs 77112101-07) showed at most a fifth of the predicted deflection. With 200 psi driver the deflection was generally less than 1 milliradian. A value of a of 1/25 mm is implied.

REFERENCES

1. S. E. Johnson, P. B. Scott and G. Watson, "Visible Chemiluminescence and Pulsed Chemical Laser Study", Xonics TR-48 (1973).

2. K. Bier and B. Schmidt, "Zür Form der Verdichtungsstöße in frei expandierenden Gasstrahlen", Z. für ang. Physik, 13, 34 (Nov 1961).

3. H. Ashkenas and R. Sherman, "The Structure and Utilization of Supersonic Free Jets in Low Density Wind Tunnels", 1964 Rarefied Gas Dynamics Symposium.

4. H. Kiepman and A. Roshko, Elements of Gasdynamics, Wiley (1957).

5. S. Goldstein, Modern Developments in Fluid Mechanics, Dover (1965), Clarendon Press, Oxford (1938).

6. Lev. A. Chernov, Wave Propagation in a Random Medium, Dover (1967), McGraw-Hill (1960).

APPENDIX D

SUMMARY OF SHOCK TUNNEL RUNS

The cross-index (below) in alphabetical order of compound precedes the detailed Summary of Runs. A run number 77110501, for instance, gives the year (1977), the month (November), the day of the month (05), and the run number (01) of that day. The driver mixture ratio is 10:20:70 (O_2:H_2:He) for all runs.

CaO	76082507-76092304, 76112401-76120903
GeO	76120904-76121305
KrF	77072602-77080205
MgF	76093001-76112303, 76121602-77022402
MgO	76092305-76092803, 78042503-
SiF	76112202-76112305
SiO	76121306-76121601, 77022801-77031501
SrO	76080501-76082506
S_2	77092801-77111704, 77121201-78042104, 78071307-78072108
XeF	77031601-77050502, 77071101-77072601, 77080401-77092603, 77112202-77120910

Run Number	Driver	Metal	Oxidizer	Comments
76080501	100 psi	300 mg SrH	200 psi N_2O	No spectrum, injection tank loaded ≤ 20 torr CO, 180 torr Ar.
76080502	"	"	"	Diffuse bands - repeat of -01, SrOH.
76080503	"	300 mg SrH + 50 mg B	"	Same.
76080504	"	300 mg SrH	"	No CO - weaker bands.
76080601	"	"	"	Repeat shot with same result.
76080602	"	"	"	Repeat shot with same result.
76080603	"	"	"	Repeat Shot with same result.
76080604	"	300 mg SrH + Boron	"	Same spectrum, slightly brighter.
76080605	"	300 mg SrH	0	CO/Ar - 20/180 torr, weak spectrum yet with no N_2O.
76080606	"	"	200 psi N_2O	
76080901	"	"	"	Cleaned shock tube before this shot, much brighter, dump tank shocks.
76080902	"	"	"	Repeat.
76080903	-	-	-	Setting Oxidizer timing.
76080904	100 psi	100 mg SrH	200 psi N_2O	CO/Ar - 20/180 torr - very weak spectrum.
76081001	50 psi	"	"	With CO - brighter.
76081002	"	300 mg SrO	"	With CO - no spectrum at all.
76081003	"	"	-	-- Very weak bands.
76081004	"	"	-	With CO - very weak bands.
76081005	100 psi	"	200 psi N_2O	200 torr CO in I.T., no Ar; shows strong bands, SrO, SrF, SrOH (?)

Run Number	Driver	Metal	Oxidizer	Comments
76081006	100 psi	300 mg SrO	200 psi N_2O	400 torr CO in I.T., same strong bands.
				Shock tube cleaned with Pasagel, steel wool, water and acetone; replaced 300 n.m. grating with 500 nm blaze grating.
76081101	"	"	"	400 torr CO in I.T., same bright spectrum as 1005, brighter.
76081201-2	-	-	-	First shot lost due to power outage, slc showed reflected D.T. shocks.
76081301-2	-	SrO	N_2O	Lost both shots, second due to D.T. diaphragm leak.
76081601	100 psi	SrO	-	With CO, weak spectrum.
76081602	"	60 mg SrO	200 psi N_2O	With 80 torr CO, Dummy Volume eliminated from system, strong spectra, SrF.
76081603	"	"	"	Repeats -02.
76081604	"	"	"	Cleaned DP valve, vinyl taped teflon insulator on spark plug, repeats.
76081605	50 psia	"	"	With CO (as prior four) - no bands in spectra.
76081606	150 psia	"	"	With CO, same bands as -01 through -04.
76081701	?	"	"	With CO, new bottle of N_2O, same spectra.
76081702	50 psia	SrH	"	With CO, no bands (only sodium D lines).
76081703	100 psia	60 mg SrO	"	Cleaned shock tube again, 80 torr CO, same spectrum.
76081801	"	"	"	With CO, 7 torr back pressure of N_2O, much less light.
76081802	"	"	"	With CO, 15 torr back pressure of N_2O, much less light than -01.
76081803	"	200 mg SrO	"	Same as -1703 but for more SrO powder, swabbed dump tank, still weak spectrum.
76081804	"	70 mg SrO	"	Twice as much CO but otherwise same as -1703, no result due to error.

Run Number	Driver	Metal	Oxidizer	Comments
76081805	100 psia	70 mg SrO	200 psi N_2O	Repeat of 1703, no spex, powder valve Ar pressure off, 1801-06!
76081806	"	"	100 psia N_2O	-1703 repeat but for powder value and N_2O pressure, weak spectrum.
76081807	150 psia	100 mg SrO	200 psi N_2O	Bright spectrum with 120 torr CO in I.T.
76081901	100 psia	60 mg SrO	"	Repeat of -1703 but driver not pumped, shot was very fast for same reason.
76081902	"	"	"	Repeat of -1703, Brewster windows added (Quartz).
76081903-4	"	"	"	He-Ne laser mirrors, (1 cm x 3 m F.L., ~ 1 M cavity).
76081905-6	"	"	"	Repeat with mirrors of higher transmission (1%), intensity too low.
76082001	"	"	"	Repeat except 50 psia rather than 500 in powder chamber.
76082002	50 psia	"	"	40 torr CO - still almost no light.
76082003	100 psia	"	"	80 torr CO, laser mirrors removed, much light.
76082004	?	?	?	Removed particle filter from D.T., cleaned D.T.
76082005	"	"	"	Repeat with 15 torr back pressure.
76082006	"	SrO	N_2O/CO	CO + N_2O (50:50) added through oxidizer, no bands, many lines.
76082301	"	"	"	75 psig CO as in -2006 but now 200 psig CO - suggestion of bands.
76082302	"	"	"	P(CO) = P(N_2O) = 200 psig.
76082303	"	60 mg SrO	"	CO rather than Ar in I.T. @ 80 torr, line spectra zone, bands return.
76082304	"	"	"	Same but with 15 torr back pressure, more light from flow.

Run Number	Driver	Metal	Oxidizer	Comments
76082305	100 psia	60 mg SrO	?	D. T. diaphragm leak(?), shock tube cleaned again.
76082401	"	"		60 torr CO in I. T., 20 torr back pressure.
76082402	"	"		Repeat but with 1% trans laser mirrors, light but no spectrum.
76082403	"	"		Repeat, looks the same.
76082404	"	"		Same as last but no back pressure, new weak bands ~ 4800Å.
76082405-6	"	"		Spex side laser mirror removed but otherwise the same.
76082407	150 psia	"	"	100 torr CO.
76082408	100 psia	"	"	Repeat of -05.
76082409	50 psia	200 mg SrH + 20 mg B	200 psi N_2O	No back pressure, no light.
76082501	100 psia	300 mg SrO	?	No back pressure, 60 torr CO in I. T., optical schematic.
76082502	"	"	"	Repeat but with 15 torr back pressure, less light.
76082503	"	"	"	Same as -02 but with 2 mirrors (1%).
76082504	"	"	"	Same but replaced spex side mirror with ~ 0.2% trans.
76082505	"	"	"	Spex side output mirror removed, otherwise the same.
76082506	"	"	"	Replaced 18' section of shock tube to reduce fluorides, shorter, same spectrum.
76082507-8	"	80 mg CaO	"	60 torr CO in I. T., 15 torr back pressure, added light @ ~ 5500Å, "CaO Green System".
76082601	"	"	"	Tried to repeat but powder did not inject.
76082602	"	"	"	Repeat of -2508.
76082603	"	200 mg CaH	200 psi N_2O	60 torr CO in I. T., no back pressure.
76082604	50 psia	"	"	11 torr back pressure, moderate CaO bands again (60 torr CO).

Run Number	Driver	Metal	Oxidizer	Comments
76082605	50 psia	200 mg CaH	200 psi N_2O	11 torr back pressure, 30 torr CO in I.T., stronger CO bands.
76082606	"	"	"	Same but 0.3% t. mirror added, black spectrum.
76082607	"	Resid. CaH	"	No back pressure, 30 torr CO, First with $\parallel$ - $\perp$ signal display.
76082608	100 psia	200 mg CaH	"	15 torr back pressure, $CaO_{\parallel}$ gain doubled.
76082609	150 psia	"	"	60 torr CO, $CaO_{\parallel}$ halved from -2608.
76082701	50 psia	"	"	15 torr He, 15 torr CO in I.T.
76082702	"	"	CO (200 psi)/ N_2O (200 psi)	40 torr He only in I.T., CO + N_2O (each 200 psi) through Ox inj; no back pressure.
76082703	"	500 mg CaH	"	50 torr He in I.T., no back pressure.
76082704	"	"	210 psi CO/ 100 psi N_2O	80 torr He in I.T., no back pressure - spex side mirror removed.
76082705	"	"	"	Repeat without back mirror.
76082706	"	"	"	160 torr He in I.T.
76082707	"	"	"	12 torr back pressure, 50 torr HE in I.T.
76083001	"	0	200 psi CO/ 200 psi N_2O	Cleaned tube with acetone.
76083002	"	50 mg CaH	"	No back pressure.
76083003	"	"	"	Mirrors in.
76083004-5	-	-	-	No notes.
76083101-4	"	"	N_2O	30 torr CO in I.T., 15 torr back pressure, IF plate.
76090101	"	"	"	Repeat of -3104 with aligned He-Ne mirrors.
76090102	"	"	"	Repeat with one mirror removed.
76090103	"	"	"	He-Ne laser induced spiking observed to be spoiled during shot.

Run Number	Driver	Metal	Oxidizer	Comments
76090301	50 psia	50 mg CaH	N_2O	200 torr CO in I.T., He-Ne mirrors replaced with 1-meter broadband mirrors.
76090302	"	"	"	60 torr CO in I.T., still very little light, driver leaked?
76090303	"	"	"	Repeat, more light.
76090304	"	"	"	Repeat of -3101-4 condition.
76090305	"	"	"	2 broadband 1-meter mirrors (1% T and 0% T).
76090701	"	10 mg CaH	Ar	Tube cleaned, pump oil changed, 15 torr pack pressure, 30 torr CO with no light.
76090801	"	"	N_2O	Same but N_2O for oxidizer, got light with $\parallel - \perp$ negative.
76090802	"	"	"	No back pressure, slightly less light.
76090803	"	"	"	30 torr CO yet, 15 torr back pressure - still has light.
76090804	"	"	"	Removed mirror.
76090805	"	50 mg CaH	Ar	30 torr CO, 15 torr back pressure, very little light.
76090806	"	"	N_2O	Same but with N_2O, normal light output, $\parallel - \perp$ negative.
76090807	"	"	"	No back pressure, about the same result.
76090901	"	"	"	30 torr CO, 15 torr back pressure.
76090902	"	"	"	Same, weak CaO spectrum.
76090403	50 psia	250 mg CaH	Ar	30 torr CO, 15 torr back pressure, no light to speak of (0.2 cm).
76090904	"	"	20 psi N_2O	Same but N_2O, ~3 cm light, $\parallel - \perp$ negative.
76090905	"	"	"	Same but no back pressure, ~2 cm light, $\parallel - \perp$ negative.
76090906	"	"	"	Signal again diminished with 15 torr back pressure (!).
76090907	"	"	"	Mirror removed, little change in traces.

Run Number	Driver	Metal	Oxidizer	Comments
76091301	50 psia	750 mg CaH	20 psi N_2O	Less light.
760913G	-	-	-	Schematic of optical calibration and standard lamp.
76091401	"	0	"	Cleaned tube, 30 torr CO, mirror removed, misaligned optics.
76091402	"	"	"	Same, shows CaO spectrum.
760914A	-	-	-	Eff of N_2O flow in spiking.
76091501	"	Residual	100 psi N_2O	30 torr CO, little light.
76091502	"	"	"	Same but mirror removed.
76091503	"	50 mg CaH	"	Same but for powder, little more light.
76091504	"	"	"	Same but mirror removed.
76091505	"	"	"	Aligned cavity again, 30 torr CO, first time $\parallel - \perp > 0$.
76091506	"	"	"	Slits opened.
76091507	"	"	"	Aligned cavity, positive again.
76091601	"	10 mg CaH	"	30 torr CO, approximately same light, comparator off?
76091602	"	"	50 psi N_2O	30 torr CO, $\parallel - \perp$ is positive.
76091603	"	"	"	Same but 15 torr N_2O back pressure, $\parallel - \perp$ is positive.
76091604	"	"	"	Same as -02 but 60 torr CO, $\parallel - \perp$ positive.
76091605	"	"	"	Same as -02 but 20 torr CO, $-\perp$ only, bad cable.
76091606	"	"	"	Same as -02 but 15 torr CO, $\parallel - \perp$ not recorded.
76091607	"	"	"	30 torr CO, mirror removed.
76091608	100 psia	50 mg CaH	100 psi N_2O	60 torr CO, D.T. reflected shocks, $\parallel - \perp$ positive.
76091701	"	"	"	60 torr CO, 15 torr back pressure.
76091702	"	"	"	Same but mirror removed.

Run Number	Driver	Metal	Oxidizer	Comments
76091703-4	-	-	-	Absorption attempts.
76091705-6	100 psia	50 mg CaH	100 psi N_2O	60 torr CO, no back pressure, absorption plate - no notable absorption.
76092001-3	"	"	"	Strobe source absorption with two 1% b.b. mirrors - no notable absorption.
76092101-5	"	"	"	Repeat, $^1P-^1S$ line absorption noted.
76092106-9	"	50 mg	N_2O or Ar	4 pass He-Ne laser attenuation, significant attenuation observed.
76092201-3	50 psia	0	0	Still attenuates about 1% per pass.
76092204	"	50 mg CaH	?	Strobed gain/abs. meas., neither indicated.
76092301-4	50 or 100	10-50 mg CaH	0-100 N_2O	30-60 torr CO, some indication of limited absorption.
76092305-7	100 psia	50 mg Mg	100 psi N_2O	60 torr CO, nozzle cleaned for -07, MgO bands & cont. A/D.
76092401	"	"	"	60 torr Ar; traces of bands, lines.
76092402	"	"	200 psi N_2O	120 torr CO; weak bands of MgO.
76092403	"	200 mg Mg	"	120 torr CO, cleaned nozzle, MgO blue system now moderately bright.
76092404	"	"	50 psi N_2O	120 torr CO, MgO weak.
76092405	"	"	200 psi N_2O	120 torr Ar - no MgO bands.
76092406	150 psia	"	250 psi N_2O	180 torr CO; brightest MgO yet.
76092407-8	"	"	"	240 torr CO, on plate.
76092409	"	"	"	120 torr CO, on plate.
76092701-5	"	"	"	180 torr CO
76092801	"	0	"	Cleaned shock tube, 180 torr CO, clean up.

Run Number	Driver	Metal	Oxidizer	Comments
76092802–76092903	150 psia	200 mg Mg	250 psi N_2O	180 torr CO, on plate.
76093001	"	0	0	Shock tube cleaned, charcoal filter added, 180 torr CO, 2 torr SF_6
76093002–3	"	0	"	180 torr CO, 2 torr SF_6, no light
76093004	"	2 mg Mg	"	180 torr CO, 2 torr SF_6, no light
76093005	"	"	200 psi N_2O	180 torr CO, 2 torr SF_6, shock too fast, first light
76093006	"	10 mg MG	"	180 torr CO, 2 torr SF_6, no light
76100101	"	"	0 (?)	180 torr CO, 2 torr SF_6, no light
76100102	"	50 mg Mg	"	180 torr CO, 2 torr SF_6, no light
76100103	"	"	200 psi N_2O	180 torr CO, 2 torr SF_6, bright & multiple shocks in DT
76100104	"	200 mg Mg	"	180 torr CO, 2 torr SF_6, bright & multiple shocks in DT
76100105	"	"	0	180 torr CO, 2 torr SF_6, still a lot of light
76100106	"	"	"	Same, plate @ 4 cm
76100107	"	"	200 psi N_2O	Same CO, SF_6, plate @ 3.5 cm
76100401	"	1 gm Mg	"	Same CO, SF_6, plate @ 6 cm
76100402	"	"	0	180 torr Ar, 2 torr SF_6, plate @ 4 cm - plate lost?
76100501–2	"	0	"	180 torr Ar + 2 torr SF_6

Run Number	Driver	Metal	Oxidizer	Comments
76100503	150 psia	10 mg Mg	0	180 torr Ar, 2 torr SF_6
76100504	"	50 mg Mg	"	180 torr Ar, 2 torr SF_6
76100505	"	10 mg Mg	"	100 torr Ar, 2 torr SF_6
76100506	"	0 (?)	"	80 torr Ar, 2 torr SF_6
76100601	"	50 mg Mg	"	100 torr Ar, 2 torr SF_6
76100602	"	10 mg Mg	"	100 torr Ar, 2 torr SF_6, back mirror blocked
76100603	"	"	"	180 torr Ar, 2 torr SF_6, nozzle & window cleaned, pellicle output, 4 m Al min, Nicol prism
76100604	"	"	"	Repeat, $\parallel > \perp$
76100701	"	"	"	Repeat with back mirror blocked
76100702	"	"	"	Same but with both mirrors
76100703	"	"	"	100 torr Ar, 4 torr SF_6
76100704	"	"	"	100 torr Ar, 1 torr SF_6
76100705	"	"	"	Same but no SF_6
76100706	"	"	"	Same but with 1/2 torr SF_6
76100707	"	20 mg Mg	"	100 torr AR, 1/2 torr SF_6
76100801	100 psia	10 mg Mg	"	67 torr Ar, 0.35 torr SF_6
76100802-5	50 psia	5 mg Mg	"	30 torr Ar, 0.2 torr SF_6, -04 with Hg lamp absorption
76100806-7	50 & 150	"	"	100 torr Ar, 1/2 torr SF_6, quartz-Halogen lamp absorption @ 361, 371 nm
76101101-3	150 psia	"	"	Same but with lamp off, -01 had pellicle covered, all with no pressure in powder valve
76101104	"	"	"	Lamp on (?)

Run Number	Driver	Metal	Oxidizer	Comments
76101105	150 psia	5 mg Mg	0	Lamp off, 2 Al laser mirrors, same otherwise
76101106	"	"	"	Same but reversed λ of detectors (350 → 361)
76101201	"	50 mg Mg	"	100 torr Ar, 1/2 torr SF_6 still, spectra from Pellicle through Nicol
76101202-3	190 psia	"	"	With and with no Nicol prism
76101301	150 psia	50 mg Mg	"	Same but Nicol prism removed
76101302	"	100 mg Mg	"	85 torr Ar, 2 torr SF_6, nozzle cleaned
76101801	"	"	"	100 torr Ar, 2 torr SF_6, monochromators following 357, 361; MgF band spectra
76101802	"	Residual	"	Same but no powder
76101803	"	"	"	Same but nozzle cleaned, still have strong MgF
76101901	"	"	"	Nozzle cleaned again, still 100/2 of Ar/SF_6
76101902-4	"	"	"	100 torr Ar, no SF_6; MgF bands weaker
76102001	"	"	"	Another repeat, MgF now hardly notable, complex line spectra
76102002	"	"	"	100 torr Ar, 2 torr SF_6, weak MgF bands
76102003	"	"	"	100 torr Ar only, plastic diaphragm in DT, not many lines!
76102004	"		"	Ar/SF_6 @ 100/2; "Handiwrap" diaphragm loses 75 mg vaporized
76102005	"	10 mg Mg	"	100 torr Ar
76102006	"	"	"	Ar/SF_6 @ 100/2, spectrum still black (Polaroid)
76102007	"	50 mg Mg	"	Ar/SF_6 @ 100/2, weak MgF appearing
76102008	"	"	"	Ar/SF_6 @ 200/4, weaker spectrum
76102101	"	"	"	Ar/SF_6 @ 100/0.5, no bands evident

Run Number	Driver	Metal	Oxidizer	Comments
76102102-3	150 psia	50 mg Mg	0	Ar/SF_6 @ 100/2, no DT diaphragm, DT → 4 torr @ shot; bright MgF
76102104	"	100 mg Mg	"	Same but for increased powder, brightness
76102105	"	200 mg Mg	"	Same but for increased powder, not as bright
76102106	"	500 mg Mg	"	Same but for increased powder, about same brightness as 05
76102107	"	"	"	Nozzle cleaned, .005" Al DT diaphragm, Ar/SF_6 @ 100/2, not as bright
76102201	"	"	"	Nozzle cleaned, Ar/SF_6 @ 100/1, very weak spectrum
76102202	"	"	"	Nozzle cleaned, Ar/SF_6 @ 100/4, equally weak
76102203	"	"	"	Nozzle cleaned, Ar/SF_6 @ 100/2, puzzling lack of agreement with 2107
76102204	"	"	"	Nozzle and S.T. cleaned, 100/2, now we again see spectra of MgF
76102205	"	"	"	Nozzle and end section cleaned, Ar/SF_6 @ 100/4 torr
76102501	"	"	"	Ar/SF_6 @ 100/8 torr
76102502	"	"	"	Nozzle and end section cleaned, Ar/SF_6 @ 100/05 torr, weak spectrum
76102503-4	"	"	"	Nozzle and end section cleaned, Ar/SF_6 @ 100/1 torr, weaker
76102505	"	100 mg Mg	"	Cleaned S.T., Ar/SF_6 @ 100/2, misaligned
76102601	"	"	"	Ar/SF_6 @ 100/4
76102602	"	500 mg Mg	"	Same but for powder, brighter
76102603	"	1 gm Mg	"	Nozzle and end section cleaned, Ar/SF_6 @ 100/4
76102604	"	500 mg Mg	"	Nozzle and end section cleaned, same but with 10 torr back pressure

Run Number	Driver	Metal	Oxidizer	Comments
76102605	150 psia	500 mg Mg	0	Same but with 20 torr back pressure
76102701	200 psia	"	"	Nozzle and end section being cleaned each shot, brighter than -05
76102702	300 psia	"	"	Still Ar/SF_6 @ 100/4
76102703-4	"	200 mg Mg	"	Tube and nozzle cleaned, Ar/SF_6 @ 100/4, on plate
76102705	"	500 mg Mg	"	Nozzle and end section cleaned, Ar/SF_6 @ 100/9
76102901	"	"	"	Nozzle and end section cleaned, Ar/SF_6 @ 100/9, two pass He-Ne absorption
76102902	"	0	"	100 torr Ar, no SF_6
76102903	"	"	"	Nozzle DT and I.T. cleaned, no SF_6, ~ 1%/pass abs after 1 ms
76102904	200 psia	"	"	100 torr Ar, no SF_6
76102905	150 psia	"	"	100 torr Ar, no SF_6
76102906	"	"	"	50 torr Ar, no SF_6
76111501	200 psia	"	"	Tube cleaned, no SF_6, 10% abs after 1 ms, 5%/pass
76111502	"	"	0 psig F_2	100 torr Ar
76111503	"	100 mg Mg	"	100 torr Ar, much less light than with SF_6, 102702 for instance
76111504	"	"	10 psig F_2	100 torr Ar, brighter
76111505	"	500 mg Mg	"	100 torr Ar, slightly brighter
76111601	"	"	0	Ar/C_2F_6 @ 100/4 torr; much brighter
76111602	"	"	20 psig F_2	100 torr Ar, spectrum brighter than 01 but traces show 01 brighter
76111603	100 psia	"	"	100 torr Ar
76111604	"	"	"	200 torr Ar

Run Number	Driver	Metal	Oxidizer	Comments
76111605	200 psia	"	"	200 torr Ar, cleaned nozzle, injector tube holes were clogged, brighter
76111606	300 psia	"	"	300 torr Ar
76111701	200 psia	"	30 psig F_2	200 torr Ar
76111702	100 psi	100 mg Mg	"	Cleaned tube, et. al., 100 torr Ar
76111801	"	"	"	Same but with both 360 nm, 99% mirrors
76111802	200 psia	"	"	100 torr Ar, 4 torr CF_6, Glan-Thompsen Polarizer added
76111803	"	500 mg Mg	"	100 torr Ar
76111804	"	"	0	100 torr Ar
76111805	200 psia	500 mg Mg	30 psig F_2	Nozzle cleaned, Ar/C_2F_6 @ 100/4 torr
76111806	"	"	0	100 torr Ar
76111901	"	"	0 psig F_2	100 torr Ar, 1.5 torr C_2F_6
76111902	100 psia	"	35 psig F_2	100 torr Ar, nozzle cleaned
76111903	300 psia	"	0 (?)	Ar/SF_6 @ 100/4, nozzle and end section cleaned
76111904	100 psia	"	50 psig F_2	100 torr Ar, no SF_6, nozzle cleaned
76112201	"	0	30 psig F_2	S. T. cleaned, Ar/SiH_4 @ 100/4
76112202	50 psi	"	40 psig F_2	Ar/SiH_4 @ 80/20 torr
76112203	"	"	"	Ar/SiH_4 @ 40/10 torr, 10 torr back pressure, SiF B-X spectra
76112301	"	"	"	Ar/SiH_4 @ 40/10 torr, no back pressure, very dim
76112302	200 psi	"	"	Ar/SiH_4 @ 90/10
76112303	50 psi	"	"	Ar/SiH_4 @ 90/10
76112304	200 psi	50 mg Si	"	100 torr Ar, weak SiF spectra

Run Number	Driver	Metal	Oxidizer	Comments
76112365	200 psi	200 mg Si	40 psig F_2	100 torr Ar, weak SiF spectra
76112401	50 psia	10 mg CaH	50 psig N_2O	S. T. cleaned, 30 torr CO, turn off air blast to chopper just before shot
76112402-5	"	"	"	Repeats of 01 with 550(∥) and 660 (∥) recorded
76112901	"	50 mg CaH	"	Same but with more CaH
76112902	"	"	"	Nozzle cleaned, repeat
76112903	"	10 mg CaH	"	Still 30 torr CO - more light with each shot
76112904	"	"	"	Moved cavity downstream by 1/2 cm, less light
76112905	"	"	"	Moved cavity upstream ~1/2 cm ahead of center
76112906	"	"	"	Repeat
76112907	"	"	"	Repeat
76113001-5	"	"	"	Repeats with changes in monitor diodes
76120101	"	"	"	Repeat
76120102	"	"	"	Same as -01 but back mirror removed
76120103-5	"	"	"	Same but 25 rather than 30 torr CO, both mirrors, scale and scope
76120106	"	"	100 psi N_2O	
76120107	"	"	50 psi N_2O	
76120108	"	"	"	Same but mirror blocked
76120109	"	"	"	Same with mirrors on
76120110	"	"	"	20 torr CO
76120111	100 psia	20 mg CaH	"	
76120201	50 psia	"	"	Lenses removed from 550 ∥ and ⊥

Run Number	Driver	Metal	Oxidizer	Comments
76120202	50 psia	200 mg CaH	50 psi N_2O	Same but without rear laser mirror
76120203	"	"	"	Ar/CO @ 15/5 torr CO
76120204	"	100 mg CaH	"	More CaH, no more light
76120205	"	"	"	Cleaned nozzle
76120206	100 psia	200 mg CaH	100 psig N_2O	
76120207	"	20 mg CaH	"	Cleaned nozzle
76120208	"	"	"	Repeat without rear laser mirror, He–Ne attenuation (2 pass)
76120301	50 psia	"	"	80% attenuation after incident shock, dropping to ~ 4% after ref-shock (2 pass)
76120302	"	0	50 psig N_2O	Everything cleaned, Brewster window reversed, now < 1% pass @ 1 ms
76120303	"	"	"	Same but with 20 torr CO rather than 20 torr Ar
76120304	"	20 mg CaH	"	Loss per pass 2% or greater
76120305	"	"	"	Ar/CO @ 15/5 torr
76120306	"	"	"	Attempt to get spectra through output mirror
76120601	"	"	"	Ca line spectrum, still Ar/CO @ 15/5
76120602	"	"	"	20 torr CO, no Ar, spectrum nearly black
76120603	100 psia	"	100 psig N_2O	Ar/CO @ 30/10 torr, stronger spectra with CaO, AlO
76120604	"	"	"	CO only @ 40 torr, black but for weak diffuse bands
76120605	"	"	"	Nozzle cleaned, He–Ne attenuation of 4–8%/pass
76120701	"	200 mg CaH	"	Now > 20% attenuation of He–Ne, Ar/CO @ 30/10 torr
76120702	200 psia	40 mg CaH	200 psig N_2O	Ar/CO @ 60/20 torr
76120702a	-	-	-	He–Ne attenuation of ~ 1%/pass with 100 psi N_2O inj., ~2% with 200 psi

Run Number	Driver	Metal	Oxidizer	Comments
76120703-5	200 psia	0	100 psig N_2O	Cleaned tube, Ar/CO @ 60/20 torr
76120706	"	"	"	Same but with 20 torr back pressure
76120707	"	"	0	Ar/CO @ 60/20 torr
76120708	"	"	100 psi N_2O	80 torr Ar, no CO
76120709	"	"	"	80 torr Ar, no CO
76120801	"	"	"	80 torr Ar, no CO
76120802-4	"	"	"	Repeat of 708, aligned cavity for -02
76120805	"	10 mg CaH	"	Ar/CO @ 60/20 torr
76120806	100 psia	"	"	Ar/CO @ 30/10
76120807	"	20 mg CaH	"	Ar/CO @ 30/10
76120808	50 psia	"	"	Ar/CO @ 30/10
76120809	100 psia	"	"	Ar/CO @ 30/10
76120810	"	"	"	Same as 09 but stainless steel screen in front of nozzle array
76120901	"	"	"	Repeat but set @ 549 nm rather than 550
76120902	"	"	"	Stainless steel screen removed, nozzle cleaned, Ar/CO remains @ 30/10
76120903	"	"	"	Same but windows cleaned, mirrors realigned
76120904	"	20 mg Ge	"	First shot with Ge this contract, 60 torr Ar, Atomic Ca & AlO in spectra
76120905	"	"	"	Repeat with 120 torr Ar
76120906	"	"	"	Repeat with aligned cavity and chopper, observing 458 and 479 nm
76120907	"	"	"	Same but with $\lambda_{\perp}$ changed

Run Number	Driver	Metal	Oxidizer	Comments
76120908	50 psia	20 mg Ge	100 psi N_2O	120 torr Ar
76120909	100 psia	"	"	120 torr Ar, windows cleaned, cavity aligned, chopper out of cavity
76121001	150 psia	"	"	Same but for driver
76121002	100 psia	"	"	Same as 905, λ changed from 45 Σ to 465 nm
76121003	"	"	"	Same as 02 but λ = 479 nm (Ge 7, 0)
76121004	"	"	"	Same but λ = 450 nm
76121005	"	"	"	Same but λ = 458 nm, slits reduced from 2 mm to 1 mm (3.3 nm)
76121006	"	"	"	Same but laser mirror off, spectrum
76121007	"	"	100 psi Ar	Same but for Ar rather than N_2O
76121008	"	0	100 psig N_2O	Ar/SiH_4 @ 180/20 torr
76121009	"	"	"	Same but nozzle cleaned
76121301	"	20 mg Ge	"	Ar/SiH_4 @ 180/20 torr
76121302	"	0	"	Nozzle, end section and D. T. cleaned, Ar/SiH_4 @ 180/20 torr
76121303	"	5 mg NaF	"	200 torr Ar, 2 torr SiH_4, nearly dark spectrum
76121304	"	5 mg Naf + 20 mg Ge	"	200 torr Ar, no SiH_4, SiO bands in spectrum, also Na, Ca, Al
76121305	"	"	100 psi Ar	200 torr Ar, line spectra only
76121306	"	20 mg Si	100 psi N_2O	200 torr Ar, SiO bands
76121307	"	"	"	400 torr Ar, no bands
76121401	"	"	"	400 torr Ar, no bands
76121402	"	200 mg Si	"	400 torr Ar, no bands

Run Number	Driver	Metal	Oxidizer	Comments
76121403	100 psia	5 mg NaF + 20 mg Si	100 psi N_2O	Nozzle cleaned, 400 torr Ar
76121404	"	"	100 psig Ar	400 torr Ar
76121405	"	"	100 psig N_2O	500 torr Ar, some band heads (weak) in spectrum
76121406	"	"	"	600 torr Ar, dark spectrum (on Polaroid)
76121407	"	"	100 psi Ar	
76121501	"	"	"	500 torr Ar
76121502	"	"	"	500 torr Ar
76121503	"	"	100 psi N_2O	500 torr Ar, still a dark spectrum
76121504	"	"	"	Ar/CO @ 450/50 torr, Na D lines suddenly appear with CO addition
76121601	"	"	"	Ar/CO @ 495/5 torr, NaD plus weak SiO band heads
76121602	150 psia	200 mg Mg	0	Wedge nozzle, Ar/C_2F_6 @ 98/2 torr, ~ 25:1 expansion ratio
76121603	"	"	"	Same but with Dove prism to rotate image 90°, 2" APC windows
76121701	200 psia	"	"	Still Ar/C_2F_6 @ 98/2 torr, brighter
76121702	"	"	"	Ar/C_2F_6 @ 48/2 torr, SiF (at least) not so bright, MgF still very bright
76121703	300 psia	"	"	Ar/C_2F_6 @ 48/2, now using 25% N.D. filter for spectrum
76121704	150 psia	"	"	Ar/C_2F_6 @ 48/2, 10% trans filter, nozzle throat opened, 8.1 expansion
76121705	200 psi	"	"	Ar/C_2F_6 @ 98/2 torr, brighter than 04
76121706	300 psi	"	"	Ar/C_2F_6 @ 98/2 torr, still brighter
76121707	100 psi	"	"	Ar/C_2F_6 @ 98/2 torr, much weaker

Run Number	Driver	Metal	Oxidizer	Comments
76121708	150 psi	200 mg Mg	100 psi N_2O	Ar/C_2F_6 @ 98/2 torr, Dove prism removed, rear laser mirror added
76122001	"	0	"	Shock tube cleaned, strong C_2, SiF, MgF, CaF bands remain
76122002	"	"	"	Bands suddenly gone, high D. T. pressure? (weak MfF band)
76122003	"	200 mg Mg	"	Still Ar/CO @ 98/2, bright MfF, many lines, traces of other bands
76122004	"	"	"	Ar/C_2F_6 @ 98/2, clogged D. T. filter cleaned, return to bands of 2001
76122101	"	"	"	Ar/C_2F_6 @ 98/2, laser mirrors added
76122102	"	"	"	Opened nozzle (2-D) to 0.5 cm, exp ratio of 4:1, spectrum brighter
76122103	"	"	"	Ar/C_2F_6 @ 98/2; $\parallel$ @ 361, $\perp$ @ 359 nm
76122104	"	"	"	Ar/C_2F_6 @ 98/2; $\parallel$ and $\perp$ @ 361 nm
76122105	"	"	"	Ar/C_2F_6 @ 98/2; cavity detuned
76122106	200 psia	"	"	Ar/C_2F_6 @ 98/2
76122107	150 psia	500 mg Mg	"	Ar/C_2F_6 @ 98/2, windows cleaned, mirrors aligned
76122108	"	200 mg Mg	"	Ar/C_2F_6 @ 96/4 torr, spectrum weaker, more defuse
76122201	"	"	"	Ar/C_2F_6 @ 99/1
76122202	"	"	"	Same but nozzle moved downstream 1.8 cm
76122203	"	"	"	Same but cavity spoiled with 10% trans filter inside cavity
76122204	"	"	"	Same but filter out
76122205	"	"	"	Ar/C_2F_6 @ 98/2 torr, filter now in path outside cavity
76122206	"	"	"	Ar/C_2F_6 @ 98/2 torr, Al mirror (4 M) on monochometer side

Run Number	Driver	Metal	Oxidizer	Comments
76122207	150 psia	200 mg Mg	100 psi N_2O	Ar/C_2F_6 @ 98/2 torr, 450-650 dielectric mirror on mono side, H Spex side
76122301	"	"	"	Repeat of 2207
76122302	"	"	"	Same but pellicle inside cavity
76122303	"	Residual	"	Ar/C_2F_6/Xe @ 88/2/10 torr
76122304	"	"	"	Same but 10% N.D. filter in front of Spex
76122305	300 psia	"	"	Same but for driver, brighter
77010401-3	"	0	"	Shock tube cleaned, Ar/Xe/C_2F_6 @ 88/10/2 torr
77010404	"	50 mg MgF_2	"	Ar/Xe @ 90/10 torr
77010501	"	"	"	100 torr Ar, 10% N.D. filter back in mono path, optics realigned
77010502	"	"	"	Repeat, windows cleaned
77010503	150 psia	200 mg MgF_2	"	100 torr Ar
77010504	"	1 gm MgF_2	"	100 torr Ar
77010505	300 psi	"	"	100 torr Ar, bolts sheared on one side of nozzle, may have been wide forward shots
77010601	150 psi	"	"	100 torr Ar, nozzle repaired, now 6 mm throat, 3.3:1 exp ratio
77010602	"	100 mg Mg + 300 mg MgF	"	100 torr Ar
77010603	"	"	"	Same but windows cleaned, mirrors realigned
77010604	"	"	"	Same but was both 450-650 diel mirrors, changed to Al mono side
77010605	"	"	"	Same but Spex side mirror removed, 10% filter over half slit, MgF bands

Run Number	Driver	Metal	Oxidizer	Comments
77010606	"	Residual	"	100 torr Ar
77010607	"	200 mg Mg	"	100 torr Ar
77010608	"	600 mg MgF_2	"	100 torr Ar
77010609	"	Residual	"	100 torr Ar
77010701	"	200 mg Mg	"	100 torr Ar, spectrum of downstream emission
77010702	"	600 mg MgF_2	"	100 torr Ar
77010703-4	"	"	"	100 torr Ar, IF plate, λ_o = 400 nm
77010705	"	"	"	100 torr Ar, IF plate with λ_o = 490 nm, 450-650 diel mirrors
77010706	"	"	"	100 torr Ar, cavity moved downstream
77010707	"	"	"	100 torr Ar, 72% He-Ne laser attenuation
77010708	"	"	"	100 torr Ar, repeat with 10Å B. P. He-Ne filter
77011001	"	"	"	100 torr Ar, cavity moved as close to nozzle as possible, ~ 10% loss/pass
77011002-4	"	Residual	"	100 torr Ar, less absorption, bright MgF
77011005	"	100 mg MgF_2	"	100 torr Ar, too much absorption
77011006-7	"	"	"	100 torr Ar, repeats
77011101	"	0	"	100 torr Ar, shock tube cleaned
77011102	"	"	"	50 torr Ar
77011103	"	"	"	90 torr Ar, 10 torr Xe
77011104	"	"	"	$Ar/Xe/C_2F_6$ @ 88/10/2, MgF bands appeared
77011105	"	"	"	Xe/C_2F_6 @ 10/2, Ar pressure not noted, dark spectrum
77011106	"	"	"	$Ar/Xe/C_2F_6$ @ 38/10/2, still dark

Run Number	Driver	Metal	Oxidizer	Comments
77011201	150 psi	0	0	Ar/Xe/C_2F_6 @ 46/3.2/1 torr, MgF bands plus
77011202	"	"	"	Ar/Xe/C_2F_6 @ 40/1/0.2 torr, line spectrum, bands weak
77011203	"	"	"	Ar/Xe/C_2F_6 @ 95/5/0.5 torr, bright bands & lines
77011301-2	"	"	"	Ar/Xe/C_2F_6 @ 65/30/5 torr - no light, bands or lines
77011303	"	"	"	Ar/Xe/SF_6 @ 88/10/2, bright bands & lines
77011304	"	"	"	Ar/Xe/SF_6 @ 44/5/1, light about halved
77011305	"	"	"	Ar/Xe/SF_6 @ 150/15/3 torr, no light out
77011401	"	"	"	Ar/Xe/SF_6 @ 90/3/5 torr, no light out
77011402	"	"	"	Ar/Xe/SF_6 @ 90/5/5 torr, no light out
77011403	"	"	"	Ar/Xe/SF_6 @ 93/5/2, some lines, MgF bands
77011404	"	"	"	Ar/Xe/SF_6 @ 88/10/2, stronger lines & bands
77011405	"	"	"	Ar/Xe/SF_6 @ 78/20/2, result similar to last shot
77011701	"	"	"	Ar/SF_6 @ 98/2, result similar to last shot
77011702	100 psia	"	"	Ar/SF_6 @ 98/2, not so bright as prior shot
77011801	300 psia	"	"	Ar/Xe/SF_6 @ 17/20/3, spectrum similar to 1702
77011802	"	"	"	Xe/SF_6 @ 20/3 torr, weaker spectrum
77011803	150 psia	"	"	Xe/SF_6 @ 20/3 torr, dark
77011901	300 psia	"	"	Repeat of 1802
77011902	150 psia	"	"	Ar/Xe/CF_3I @ 98/1/1 torr; MgF bands, many lines, CH bands
77011903	300 psia	"	"	Ar/Xe/CF_3I @ 49/0.5/0.5; weaker spectrum
77011904	150 psia	"	"	Ar/Xe/CF_3I @ 147/1.5/1.5 torr, spectrum
77011905	"	"	"	Ar/Xe/CF_3I @ 200/2/2, spectrum not as bright

Run Number	Driver	Metal	Oxidizer	Comments
77012001	150 psia	100 mg MgF_2	0	Ar/CF_3I @ 200/2, same spectrum
77012002	"	"	"	$Ar/Xe/CF_3I$ @ 300/3/3 - much dimmer
77012003	"	"	"	$Ar/Xe/CF_3I$ @ 247/50/3 - still dimmer
77012004	"	"	"	Ar/CF_3I @ 300/3, moderate intensity, high v side of MgF bands light
77012005	"	"	"	Ar/CF_3I @ 254/6, dim, almost dark
77012006	"	"	"	Ar/CF_3I @ 300/3, like 2004
77012007	"	"	"	Ar/CF_3I @ 300/0.5, like 2004 but less intense
77012101	"	"	"	Ar/CF_3I @ 300/1, bright again, less low v' light than 2004
77012102	"	"	"	Ar/SF_6 @ 300/0.5, spectrum near identical
77012103	"	"	"	Ar/SF_6 @ 200/0.4; brighter
77012104	100 psia	"	"	Ar/SF_6 @ 200/0.4; dimmer
77012105	150 psia	"	"	Ar/SF_6 @ 300/0.5; cleaned end section of S.T., dark spectrum
77012106	"	"	"	Ar/SF_6 @ 300/0.5; MgF bands returned
77012401	"	"	"	Ar/SF_6 @ 300/0.5; too bright, shock too fast - discard
77012501	"	"	"	Ar/SF_6 @ 300/0.5, 360 nm mirror on monochrometer side, $\lambda_{\parallel} = \lambda_{\perp} = 361$
77012502	"	"	"	Ar/SF_6 @ 300/0.5, 360 nm mirror on Spex side too
77012503	"	"	"	Ar/SF_6 @ 200/0.5
77012504	"	100 mg MgF_2	"	200 torr Ar
77012505	"	"	"	100 torr Ar
77012506	"	"	"	Ar/SF_6 @ 100/0.5
77012507	"	500 mg MgF_2	"	100 torr Ar

Run Number	Driver	Metal	Oxidizer	Comments
77012508	150 psia	200 mg Mg	0	100 torr Ar
77012601-3	200 psi	"	"	Ar/C_2F_6 @ 98/2 torr
77012604-6	150 psi	"	"	Ar/C_2F_6 @ 98/2 torr
77012701-2	"	"	"	Ar/C_2F_6 @ 98/2 torr (repeat of 2604-)
77012703	"	"	"	End of shock tube cleaned, new 1 cm spaced parallel plate nozzle, 98/2
77012704-03	"	"	"	Ar/C_2F_6 @ 200/2 torr
77012804	200 psia	"	"	Ar/C_2F_6 @ 100/2 torr
77012805	"	"	"	Ar/C_2F_6 @ 99/1
77012806	"	Residual	"	$Ar/Xe/C_2F_6$ @ 98/1/1
770129--	-	-	-	Calibrated with standard lamp
77013101	300 psia	200 mg Mg	"	Ar/C_2F_6 @ 100/2
77013102	"	0	"	Cleaned tube, et. al., with steel wool, water, acetone, $Ar/Xe/C_2F_6$ @ 47.5/2/0.5
77013103	"	"	"	$Ar/Xe/SF_6$ @ 97.5/2/0.5 torr
77020101	"	"	"	$Ar/Xe/SF_6$ @ 80/2/0.7
77020102	"	"	"	Nozzle cleaned; $Ar/Xe/SF_6$ @ 100/2/0.5
77020103	"	"	"	$Ar/Xe/SF_6$ @ 88/10/2; bright
77020104	"	"	"	Ar/SF_6 @ 96/4, dimmer
77020105	"	"	"	$Ar/Xe/SF_6$ @ 76/20/4, still dimmer
77020106	"	"	"	$Ar/Xe/SF_6$ @ 26/20/4, very weak
77020107	"	"	"	Ar/SF_6 @ 48/2, not quite so weak
17020201	"	"	"	Ar/SF_6 @ 49/1, same intensity

Run Number	Driver	Metal	Oxidizer	Comments
77020202	200 psia	0	0	Ar/SF_6 @ 49/1, bright
77020203	100 psia	"	"	Ar/SF_6 @ 49/1, bright
77020204	50 psia	"	"	Ar/SF_6 @ 49/1, weak MgF bands
77020205	100 psia	"	"	Ar/SF_6 @ 49/1, both mirrors on
77020206	"	"	"	Ar/SF_6 @ 49.4/0.6
77020301-4	"	"	"	Ar/SF_6 @ 49/1, last two shots make Polaroid spectrum
77020305-6	"	"	"	Ar/SF_6 @ 48.5/1.5, last two shots make Polaroid spectrum
77020307-8	"	"	"	Ar/SF_6 @ 75/1, last two shots make Polaroid spectrum
77020309	"	"	"	Ar/SF_6 @ 29/1
77020310	"	"	"	Ar/SF_6 @ 29.4/0.7
77020311	"	"	"	Ar/SF_6 @ 100/0.5
77020401	"	"	"	Ar/SF_6 @ 49.3/0.7, removed Spex side laser mirror and lens
77020402	"	"	"	Ar/SF_6 @ 29.5/0.5
77020403	"	"	"	Ar/SF_6 @ 29.5/0.5, mirror back on
77020404	"	"	"	Ar/SF_6 @ 99.5/0.5
77020405	"	"	"	Ar/SF_6 @ 49.3/0.7
77020406	"	"	"	Ar/SF_6 @ 49.3/0.7
77020701	"	"	"	Ar/SF_6 @ 29.5/0.5
77020702	"	"	"	Ar/SF_6 @ 29.4/0
77020703-5	"	50 mg Mg	"	Ar/SF_6 @ 49/1
77020706	"	"	"	Ar/SF_6 @ 48.5/1.5
77020707	"	"	"	Ar/SF_6 @ 49.3/0.7

Run Number	Driver	Metal	Oxidizer	Comments
77020801-3	100 psia	150 mg MgF_2	0	50 torr Ar, 30 shot spectrum showing isolated band @ ~340 nm
77020804	"	Residual	"	Ar/SF_6 @ 49/1, same band @ 340 nm
77020805	"	300 mg MgF_2	"	50 torr Ar, nothing through mirrors
77020806-7	"	"	"	50 torr Ar, two shots on Polaroid spectrum, weak 340 band
77020808	"	Residual	"	Ar @ 50 torr
77020901-2	"	"	"	Ar/SF_6 @ 49/1
77020903-4	"	50 mg Mg	"	Ar/SF_6 @ 49/1, without and with mirror on Spex side
77020905	"	"	"	Ar/SF_6 @ 49/1, cavity detuned
77020906	50 psia	"	"	Ar/SF_6 @ 29/1
77020907	"	"	"	Ar/SF_6 @ 49/1
77020908	100 psia	100 mg Mg	"	Ar/SF_6 @ 49/1
77021101-2	"	50 mg Mg	"	Ar/SF_6 @ 49/1
77021103	"	200 mg Mg	"	Ar/SF_6 @ 49/1
77021104	"	800 mg Mg	"	Ar/SF_6 @ 49/1
77021105	"	Residual	"	Ar/SF_6 @ 49/1
77021106	"	50 mg Mg	"	Ar/SF_6 @ 29/1
77021107	50 psia	"	"	Ar/SF_6 @ 29/1
77021401	"	100 mg Mg	"	Ar/SF_6 @ 29/1, aligned and windows cleaned
77021402-3	"	200 mg Mg	"	Ar/SF_6 @ 29/1
77021404	"	100 mg Mg	"	Ar/SF_6 @ 29.5/0.5, powder valve leaking
77021501	"	"	"	Ar/SF_6 @ 29.5/0.5, fixed powder valve
77021502	"	"	"	Ar/SF_6 @ 29/1

Run Number	Driver	Metal	Oxidizer	Comments
77021503	50 psia	100 mg Mg	0	Ar/SF_6 @ 28/2
77021504	100 psia	"	"	Ar/SF_6 @ 29/1
77021505	"	"	"	Ar/SF_6 @ 29/1, same but cavity spoiled by tilting mirrors
77021506	50 psi	"	"	Ar/SF_6 @ 29/1, windows cleaned, mirrors aligned
77021507	"	"	"	Ar/SF_6 @ 29/1
77021601	"	"	"	Ar/SF_6 @ 29/1, IO plate, Spex side mirror out, 3 cm
77021602-5	"	"	"	Ar/SF_6 @ 29/1, 4 shots in IO plate, 4 cm, (50 μ slits)
77021701	"	"	"	Ar/SF_6 @ 29/1, 2 cm on IF plate, 10-20 μ slits
77021702	"	"	"	30 torr Ar, 3 cm position
77021703	200 psia	"	"	Ar/SF_6 120/1, also @ 3 cm (!)
77021704	50 psia	"	"	30 torr Ar, repeat of 02 @ 4 cm (last on plate)
77021705	"	"	"	Ar/SF_6 @ 29/1, new IF plate, 2 cm
77021706	300 psia	"	"	Ar/SF_6 @ 29/1, 3 cm
77021707	"	"	"	Ar/SF_6 @ 200/1, 4 cm
77021708	"	"	"	200 torr Ar, 5 cm (last on plate)
77021801	"	"	"	Ar/Xe @ 190/10 torr
77022201-2	300 psi	0	0	End section cleaned, 20 torr Xe, without and with laser mirrors (360 nm)
77022203-4	"	"	"	20 torr Xe, repeat without and with mirrors; bright lines, bands without buildup
77022205	"	"	"	Same with mirrors misaligned, not changed
77022206-7	100 psi	"	"	20 torr Xe, misaligned and then aligned, minor change
77022208	300 psi	"	"	Xe/SF_6 @ 20/0.5

Run Number	Driver	Metal	Oxidizer	Comments
77022301	300 psi	0	0	Xe/SF_6 @ 19/1
77022302	50 psia	"	"	Xe/SF_6 @ 19/1
77022303-4	300 psia	"	"	Xe/SF_6 @ 16/4, mirrors in and out - very bright, lines plus MgF bands
77022305	"	"	"	Xe/SF_6 @ 16/4, mirror in and aligned, no buildup evident from spectrum
77022306	"	"	"	Xe/SF_6 @ 1/19, no light
77022307	"	"	"	Ar/Xe @ 20/0.5
77022308	"	50 mg Mg	"	Ar/SF_6 @ 16/4, IF plate, 2 cm
77022401	"	Residual	"	Ar/SF_6 @ 16/4, 3 cm
77022402	"	"	"	Xe/SF_6 @ 16/4, 4 cm
77022801	200 psia	"	100 psi N_2O	Ar/SiH_4 @ 19/1, weak SiO D→X on Polaroid
77022802	50 psia	"	"	Ar/SiH_4 @ 19/1, strong SiO D→X plus lines
77022803	"	"	"	Ar/SiH_4 @ 29/1, bright D→X
77022804	"	"	"	Ar/SiH_4 @ 49/1, bright D→X
77022805	"	"	"	Ar/SiH_4 @ 25/5, dark (Polaroid)
77022806	"	"	50 psi N_2O	Ar/SiH_4 @ 29/1, bright D→X
77022807	"	"	150 psig N_2O	Ar/SiH_4 @ 29/1, weaker D→X
77022808	40 psia	"	100 psi N_2O	Ar/SiH_4 @ 29/1, bright D→X, but weaker than 2803
77022809	50 psia	"	50 psi N_2O	Ar/SiH_4 @ 29/1, looking downstream with Spex, no spectrum
77030101	"	"	"	Ar/SiH_4 @ 29/1, very bright near nozzle
77030102	"	"	"	30 torr Ar, lines, weak SiO bands
77030103	"	"	"	Ar/SiH_4 @ 29.7/0.3, moderate SiO D→X

Run Number	Driver	Metal	Oxidizer	Comments
77030104	50 psia	Residual	50 psi N_2O	Ar/SiH_4 @ 27/3, slightly stronger SiO bands
77030105	"	"	"	Ar/SiH_4 @ 29/1, no D.T. diaphragm, dimmer SiO
77030106	"	"	"	Ar/SiH_4 @ 29.4/0.6, still weaker (powder valve off)
77030107	"	"	"	Ar/SiH_4 @ 28.5/1.5, bright (powder valve off)
77030108	"	"	"	Ar/SiH_4 @ 36.5/1.5, nearly as bright as 3101
77030109	"	"	"	Ar/SiH_4 @ 37/1
77030201	"	"	"	Ar/SiH_4 @ 36.5/1.5
77030202	"	"	"	End section cleaned, 30 torr Ar
77030203	"	"	"	Repeat, monochrometer on 270, 304 nm
77030204	"	"	"	Repeat
77030205	"	"	"	Ar/SiH_4 @ 30/0.1
77030206	"	"	"	Ar/SiH_4 @ 37.8/0.2
77030207	"	"	"	Ar/SiH_4 @ 30/0.3
77030208-9	"	"	"	Ar/SiH_4 @ 37.5/0.5
77030301	"	20 mg Mg	"	Ar @ 30 torr
77030302	"	20 mg Si	"	Ar @ 30 torr
77030303	"	100 mg Si	"	Ar @ 30 torr
77030304	"	100 mg SiO	" (?)	Ar @ 30 torr, weak SiO D→X
77030305	"	200 mg SiO	"	Ar @ 30 torr, stronger D→X
77030306-7	"	"	0	Ar @ 30 torr
77030308	"	"	"	Ar @ 30 torr, cleaned end section
77030401	200 psia	200 mg Si	0	Ar @ 200 torr

Run Number	Driver	Metal	Oxidizer	Comments
77030402	50 psia	200 mg Si	50 psig N_2O	Ar @ 30 torr
77030403	"	"	"	Ar @ 30 torr
77030404-6	40 psia	"	"	Ar @ 30 torr, tube cleaned, IF plate - 2 cm; He-Ne; 4%/pass
77030701	"	"	"	Ar @ 30 torr, moderate SiO D→X
77030702	"	Residual	"	Ar @ 30 torr, much brighter D→X than -01
77030703-4	"	"	"	Ar @ 30 torr, both on one Polaroid
77030705	50 psia	"	"	Ar @ 30 torr, nozzle and tube cleaned
77030706	"	20 mg Si	"	Ar @ 30 torr
77030707	"	"	"	Ar @ 30 torr, on IO plate, 2 cm
77030708-9	"	40 mg Si	"	Ar @ 30 torr, also @ 2 cm
77030801	100 psia	"	"	Ar @ 80 torr
77030802	50 psia	"	"	Ar @ 30 torr, 360 nm, 1% T laser mirrors on, observing 365 nm
77030803	"	"	"	Ar @ 30 torr
77030804	"	"	"	Ar @ 30 torr, $\parallel > \perp$
77030805	"	"	"	Ar @ 30 torr, $\parallel > \perp$
77030806-7	"	"	"	Ar @ 30 torr
77030901	"	"	"	Ar @ 30 torr, $\parallel > \perp$
77030902	"	"	"	Ar @ 60 torr, $\parallel > \perp$
77030903	"	"	0	Ar/N_2O @ 20/10; very little light
77030904	"	"	50 psi N_2O	Ar @ 60 torr
77030905	"	"	"	Ar @ 200 torr, no light

Run Number	Driver	Metal	Oxidizer	Comments
77030906-8	100 psia	Residual	50 psi N_2O	He/SiH_4 of 40/0.5
77031001	"	"	"	He/SiH_4 of 39/1, optics viewing 2-3 cm downstream, weak SiO
77031002	200 psia	"	"	He/SiH_4 of 90/10, dark (on Polaroid)
77031003-4	100 psia	"	"	He/SiH_4 of 40/1, weak SiO $D \rightarrow X$
77031501	"	40 mg Si	150 psi N_2O	Ar @ 40 torr
77031601	300 psia	0	10 psig F_2	Tube, nozzle, dump and injection tanks cleaned, Ar/Xe @ 18/2
77031602	100 psia	"	20 psig F_2	Shows diffuse band ~350 nm Ar/Xe @ 18/2
77031603	"	"	30 psig F_2	Ar/Xe @ 18/2, intensity up by four from 02
77031604	"	"	"	Ar/Xe @ 18/2, Brewster windows and 360 nm mirrors added
77031605	"	"	"	Ar/Xe @ 18/2, repeat but detuned cavity
77031606	"	"	25 psig F_2	Ar/Xe @ 38/2, cavity aligned, $E_{\parallel}/E_{\perp} \cong 18$
77031607	"	"	20 psig F_2	Ar/Xe @ 38/2, similar enhancement
77031701	"	"	30 psig F_2	Ar/Xe @ 38/2, realigned and reduced aperture
77031702	"	"	25 psig F_2	Ar/Xe @ 38/2
77031703	"	"	"	Ar/Xe @ 58/2, less light
77031704	"	"	20 psig F_2	Ar/Xe @ 38/1, $\parallel/\perp \cong 8$
77031705	"	"	"	Ar/Xe @ 38/1, repeat with detuned cavity
77031706	"	"	25 psig F_2	Ar/Xe @ 39/1
77031707	200 psia	"	"	Ar/Xe @ 79/1, little light
77031708	100 psia	"	He/F_2 @ 176/24 psi	Ar/Xe @ 39/1, bright again
77031801	"	"	25 psig F_2	Ar/Xe @ 39/1, 10 torr Ar backpressure

Run Number	Driver	Metal	Oxidizer	Comments
77031802	50 psi	0	"	Ar/Xe @ 18/1
77031803	"	"	"	Ar/Xe @ 18/1 - D.T. diaphragm opened only half
77031804	"	"	20 psig F_2	Ar/Xe @ 19/1
77032101-3	"	"	25 psig F_2	Ar/Xe @ 19/1, all three on one Polaroid spectrum
77032104	"	"	"	Ar/Xe @ 14/1
77032201	"	"	30 psi F_2	Ar/Xe @ 14/1, Spex side mirror removed
77032202	"	"	"	Ar/Xe @ 14/1, repeat with aligned cavity, clean mirrors, $E_{\parallel}/E_{\perp} = 15$
77032203	"	"	35 psi F_2	Ar/Xe @ 14/1
77032204	"	"	"	Ar/Xe @ 14/1, repeat with slightly detuned cavity
77032205	"	"	"	Ar/Xe @ 14/1, repeat, detuned 3 divisions
77032206	150 psi	"	30 psig F_2	Ar/Xe @ 100/5
77032207	"	"	35 psig F_2	Ar/Xe @ 42/3
77032301	"	"	"	Ar/Xe @ 42/3
77032302	"	"	"	Ar/Xe @ 44/1, more light but low $\parallel/\perp$
77032303	"	"	"	Ar/Xe @ 44.5/0.5
77032304	"	"	"	Ar/Xe @ 44.7/0.26
77032305	200 psia	"	"	Ar/Xe @ 54/1, very little light
77032306	150 psia	"	"	Ar/Xe @ 44/1, Spex side mirror out glass Dove prism
77032307	"	"	"	Ar/Xe @ 44/1, aligned mirrors, prism (Dove) out, $E_{\parallel}/E_{\perp} = 7.4$
77032308	"	"	"	Ar/Xe @ 44/1, same but detuned by 3 divisions, $E_{\parallel}/E_{\perp} = 5.6$

Run Number	Driver	Metal	Oxidizer	Comments
77032401	150 psia	0	40 psi F_2	Ar/Xe @ 44/1
77032402	"	"	"	Ar/Xe @ 44/1 torr
77032403	"	"	"	Ar/Xe @ 44/1 torr, cavity moved 2-3 mm downstream
77032404	"	"	"	Ar/Xe @ 44/1 torr, cavity moved 5 mm upstream from 03
77032405-8	"	"	"	Ar/Xe @ 44/1 torr, IO plate @ 2 cm
77032501	"	"	"	Ar/Xe @ 44/1 torr, plate @ 3 cm
77033101	50 psi	"	~15 psig F_2	Ar/Xe @ 44/1 torr, He-Ne attenuation 0→1%/pass
77033102	150 psi	"	?	Ar/Xe @ 44/1 torr, He-Ne attenuation varies from 1→10%/pass
77033103	"	"	35 psi F_2	Ar/Xe @ 44/1 torr, attenuation less than on 02
77040101	"	"	"	Ar/Xe @ 44/1 torr, 100Å He-Ne filter added, still att. >1%
77040102	"	"	"	Ar/Xe @ 44/1 torr, thicker D.T. diaphragm, doesn't help
77040103	"	"	"	Ar/Xe @ 44/1 torr, deeper scribe on diaphragm, improved (?)
77040104	"	"	"	Ar/Xe @ 44/1 torr, deeper scribe yet
77040401-2	"	"	20 psi F_2	Ar/Xe @ 44/1 torr, S.T. cleaned, ≤4% absorption
77040403	"	"	"	Ar/Xe @ 44/1 torr, repeat, I.O. plate @ 2 cm
77040501	"	"	"	Ar/Xe @ 44/1 torr, plate @ 3 cm
77040502-5	"	"	"	Ar/Xe @ 44/1 torr, plate @ 4 cm, laser mirrors on
77040601	300 psia	"	"	Ar/Xe @ 98/2, F plate @ 2 cm
77040602	"	"	"	Ar/Xe @ 99/1, plate @ 3 cm
77040603	200 psia	"	"	Ar/Xe @ 59/1, plate @ 4 cm
77040604	"	"	"	Ar/Xe @ 58/2, plate @ 5 cm
77040701	"	"	"	Ar/Xe @ 56/4, plate @ 6 cm

Run Number	Driver	Metal	Oxidizer	Comments
77040801	300 psia	0	20 psi F_2	Ar/Xe @ 96/4, IF plate @ 2 cm
77040802	"	"	"	Ar/Xe @ 90/10, plate @ 3 cm
77040803	"	"	"	Ar/Xe @ 140/10, plate @ 4 cm
77040804	"	"	"	Ar/Xe @ 200/10, plate @ 5 cm
77041901	"	"	25 psig F_2	Ar @ 100 torr, 0 plate @ 2 cm
77041902	150 psia	"	"	Ar @ 45 torr, plate @ 4 cm
77041903	100 psia	"	"	Ar @ 30 torr, plate @ 5 cm
77041904	50 psia	"	"	Ar @ 15 torr, plate @ 6 cm
77041905	"	"	"	Ar @ 5 torr, plate @ 7 cm
77042101	"	"	"	Ar @ 15 torr, Polaroid spectrum, lines only
77042601	"	"	"	Ar @ 15 torr, IO plate @ 3 cm
77042602	150 psia	"	"	Ar @ 45 torr, plate @ 4 cm
77042603	300 psia	"	"	Ar @ 100 torr, plate @ 5 cm
77042901	"	"	0	Ar @ 100 torr, He-Ne attenuation of 0 to 40%
77042902	"	"	"	Ar @ 100 torr, S.S. screen on nozzle
77050201	"	"	"	Ar @ 100 torr, same but beam moved downstream
77050202	"	"	"	Ar @ 100 torr, screen removed
77050203-4	"	"	"	Ar @ 100 torr
77050205	"	"	20 psig F_2	Ar/Xe @ 90/10 torr
77050301	"	"	"	Ar/Xe @ 90/10 torr, carefully aligned to give maximum intensity through apertures
77050302	"	"	"	Ar/Xe @ 90/10 torr, larger aperture, lensing effect noted

Run Number	Driver	Metal	Oxidizer	Comments
77050303	300 psia	0	20 psig F_2	Ar/Xe @ 90/10 torr, cavity aligned
77050304	150 psia	"	"	Ar/Xe @ 41/4
77050401	300 psia	"	"	Ar/Xe @ 90/10
77050402	"	"	"	Ar/Xe @ 90/10, same but for Spex side mirror out
77050403	150 psia	"	"	Ar/Xe @ 41/4
77050501	"	"	"	Ar/Xe @ 41/4, cavity aligned, still 2 mm downstream of center
77050502	"	"	"	Ar/Xe @ 43/2
77061001	"	"	S_2Cl_2	50 torr Ar
77061002	300 psia	"	20 psi S_2Cl_2	50 torr Ar
77061003	150 psia	"	40 psi S_2Cl_2	100 torr Ar
77061004	50 psi	50 mg Al	20 psi S_2Cl_2	50 torr Ar
77061005	"	"	Valve off	50 torr Ar
77061301	150 psi	"	0	100 torr Ar
77061302	"	"	10 psi S_2Cl_2	100 torr Ar
77061303	"	"	0 psig S_2Cl_2	100 torr Ar
77061401	"	"	-5 psig S_2Cl_2	100 torr Ar
77061501	"	"	"	100 torr Ar
77071101	"	Residual	20 psig F_2	Oxidizer valve replaced, nozzle cleaned, repassivated, Ar/Xe @ 44/1
77071201	50 psia	"	"	Ar/Xe @ 14/1, Xe radiation @ ~340 nm
77071202-4	"	"	"	Ar/Xe @ 14/1, repeat of 01
77071205-6	150 psi	"	"	Ar/Xe @ 44/1 - no Xe_2 radiation
77071301-2	50 psia	"	"	Cleaned nozzle, Ar/Xe @ 14/1, strong Xe_2 radiation

Run Number	Driver	Metal	Oxidizer	Comments
77071303-5	50 psia	Residual	20 psig F_2	Ar/Xe @ 19/1, added mirror to Spex side, aligned cavity, $\parallel/\perp$ measured
77071306-7	"	"	"	Ar/Xe @ 19/1, Spex side mirror off
77071308	"	"	5 psig F_2	Ar/Xe @ 19/1, mirror on again, $\parallel/\perp \geq 10$, highest yet
77071401	"	"	-7 psig F_2	Ar/Xe @ 19/1
72071402	"	"	5 psi F_2	Ar/Xe @ 19/1, repeat of 1308, $\parallel/\perp \cong 16$
77071403	"	"	"	Ar/Xe @ 18/2
77071404	"	"	"	Ar/Xe @ 19.5/0.5
77071801-2	100 psi	"	"	Ar @ 40 torr, no evident ArF @ 190 nm
77071803	"	"	20 psi F_2	Ar @ 20 torr
77071804	200 psia	"	"	Ar/Xe @ 78/2, aligned cavity
77072001	50 psi	0	5 psig F_2	Ar/Xe @ 14/1 torr, 0 plate @ 6.5 cm
77072002	"	"	"	Ar/Xe @ 19/1 torr, plate @ 6 cm
77072101	"	"	"	Ar/Xe @ 29/1, plate @ 5.5 cm
77072102	"	"	"	Ar/Xe @ 39/1, plate @ 5 cm
77072103-4	"	"	"	Ar/Xe @ 19/1, plate @ 4.5 cm, 4 cm
77072105	"	"	"	Ar/Xe @ 19/1, Polaroid spectrum
77072201	"	"	"	Ar/Xe @ 19/1
77072202	"	"	"	Ar/Xe @ 19.5/0.5
77072203	"	"	"	Ar/Xe @ 18/2
77072204	100 psi	"	"	Ar/Xe @ 29/1
77072205	"	"	"	Ar/Xe @ 49/1
77072206	"	"	"	Ar/Xe @ 49/1

Run Number	Driver	Metal	Oxidizer	Comments
77072501	50 psi	0	5 psig F_2	Ar/Xe @ 19/1, retuned cavity, very bright
77072502-3	"	"	"	Ar/Xe @ 19/1, now not bright (??)
77072504	"	"	"	Ar/Xe @ 19/1, brighter
77072601	"	"	"	Ar/Xe @ 19/1, driver fill valve cleaned, mirrors realigned, moderately bright
77072602	"	"	"	Ar/Kr @ 28/2, cleaned nozzle, DP valve and injection valve
77072701	"	"	"	Ar/Kr @ 29/1
77072702	"	"	"	Ar/Kr @ 29.5/0.5
77072703	"	"	"	Ar/Kr @ 19/1
77072704	"	"	"	Ar/Kr @ 14/1
77072705	100 psi	"	"	Ar/Kr @ 30/10
77072801	"	"	"	Ar/Kr @ 21/1
77072802	"	"	"	Ar/Kr @ 39/1
77072803	"	"	"	Ar/Kr @ 79/1
77072804-5	"	"	"	Ar/Kr @ 120/1, timing not uniform, F_2 injection not uniform from shot to shot
77072806	"	"	"	Ar @ 120 torr
77072901	50 psia	"	"	Ar/Kr @ 10/0.5, 0 plate @ 7 cm
77072902	"	"	"	10 torr Ar, plate @ 6.3 cm
77072903	"	"	"	Ar/Kr @ 20/1, plate @ 5.5 cm
77072904	"	"	"	20 torr Ar, plate @ 4.8 cm
77072905	100 psia	"	"	Ar/Kr @ 10/1
77072906	"	"	"	Ar/Kr @ 20/1

Run Number	Driver	Metal	Oxidizer	Comments
77072907	100 psia	0	5 psig F_2	Ar/Kr @ 200/10
77072908	"	"	"	200 torr of Ar
77080101	50 psia	"	"	Ne/Kr @ 15/0.5
77080102	"	"	"	Ne/Kr @ 10/0.5
77080201	"	"	"	10 torr Ne, no drop in F_2 pressure
77080202	100 psi	"	"	20 torr Ne, 1/2 torr Kr, zero drop in F_2 again
77080203	"	"	"	20 torr Ne, 1/2 torr Kr, repeat of 02, F_2 pressure $\Delta P = 2$ psi, Kr_2 in spectrum
77080204	"	"	"	Ne/Kr @ 30/1, $\Delta P_{F_2} = 1$ psi, no K_{r_2} radiation
77080205	200 psia	"	"	Ne/Kr @ 40/1, $\Delta P_{F_2} = 4$ psi, K_{r_2} radiation weak
77080401	"	"	"	Ne/Xe @ 15/1, $\Delta P_{F_2} = 3$ psi, 0 plate @ 2 cm
77080901	50 psia	"	Same but reads 25 psia	Reset oxidizer gauge to read PSIA, Ne/Xe @ 10/0.5, $\Delta P_{F_2} = 7$, 7 cm
77080902	"	"	"	Ne/Xe @ 10/0.5, $\Delta P = 5$ psi, plate @ 6 cm
77080903	"	"	"	Ne/Xe @ 10/0.5, Polaroid
77080904	"	"	"	Ne/Xe @ 20/1, $\Delta P = 7$, not very bright
77080905	"	"	"	Ne/Xe @ 30/1, $\Delta P = 7$
77080906	100 psia	"	"	Ne/Xe @ 30/1, $\Delta P_{F_2} = 7$, very bright
77080907	150 psia	"	"	Ne/Xe @ 45/1
77080908	100 psia	"	"	Ne/Xe @ 25/1, very bright
77081001	"	"	"	Ne/Xe @ 25/1, attempt to repeat 0908, windows, mirrors cleaned, aligned; $\Delta P_{F_2} = 0$
77081002	"	"	"	Ne/Xe @ 25/1, repeat but for hole in D.T. diaphragm, $\Delta P_{F_2} =$ 7 psi, moderately bright

Run Number	Driver	Metal	Oxidizer	Comments
77081003	100 psia	0	25 psia F_2	Ne/Xe @ 25/1, repeat, $\Delta P_{F_2} = 5$, over half as bright as 0908, $\parallel/\perp < 4$
77081004	"	"	"	Ne/Xe @ 30/1, $\Delta P_{F_2} = 2$, dim
77081005	"	"	"	Ne/Xe @ 30/1, $\Delta P_{F_2} = 0$
77081006	"	"	"	Ne/Xe @ 30/1, $\Delta P_{F_2} = 5$, moderately bright
77081101	"	"	"	Ne/Xe @ 9/1, $\Delta P_{F_2} = 0$, 0 plate @ 5 cm
77081102	"	"	"	Ne/Xe @ 20/1, $\Delta P_{F_2} = 6$, plate @ 4 cm
77081103	"	"	"	Ne/Xe @ 30/1, $\Delta P_{F_2} = 4$, plate @ 3 cm
77081104	"	"	"	Ne/Xe @ 40/1, $\Delta P_{F_2} = 1/2$, plate @ 2 cm
77081105	200 psia	"	"	Rebuilt oxidizer valve, Ne/Xe = 20/1, $\Delta P = 11$ psi, 7 cm
77081106	"	"	"	Ne/Xe @ 40/1, $\Delta P_{F_2} = 11$ (until further noted, for 25 psia initial, $\Delta P_{F_2} = 11$)
77081107	100 psia	"	"	Ne/Xe @ 30/1, very bright $E_\parallel/E_\perp \cong 9$
77081201	"	"	"	Ne/Xe @ 30/1, Spex side laser mirror out, very bright
77081202	"	"	"	Ne/Xe @ 30/1
77081203	50 psia	"	"	Ne/Xe @ 20/1
77081204	"	"	"	Ne/Xe @ 20/1, bright
77081501	"	"	"	Ne/Xe @ 13/2, 0 plate @ 7 cm
77081502	"	"	"	Ne/Xe @ 14.5/0.5, plate @ 6 cm
77081503	"	"	"	Ne/Xe @ 9.5/0.5, plate @ 5 cm
77081504	"	"	"	Ne/Xe @ 19.5/0.5, plate @ 4 cm
77081505	"	"	"	Ne/Xe @ 19/1, plate @ 3 cm
77081506	"	"	"	Ne/Xe @ 19/1, plate @ 2 cm

Run Number	Driver	Metal	Oxidizer	Comments
77081507	50 psia	0	25 psia F_2	Ne/Xe @ 20/1
77081601	"	"	"	20 torr Xe, almost no light
77081602	100 psia	"	"	20 torr Xe, small amount of light
77081603	"	"	"	20 torr Xe, all prior shots were with Xe + 2% SF_6, no light
77081604	50 psia	"	40 psia F_2	Ne/Xe @ 20/1
77081605	"	"	25 psia F_2	Ne/Xe @ 19/1
77081606	"	"	"	Ne/Xe @ 20/1
77081701-5	"	"	"	Ne/Xe @ 20/1, making changes in Kistler trigger amplifier
77081706	"	"	"	20 torr Ne
77081801-2	"	"	"	20 torr Ne
770 81803-6	"	"	"	Ne/Xe-SF_6 @ 19/1, attempts to get brightness fail
77081807	"	"	0	Ne/Xe-SF_6 @ 19/1, dark
77081808	100 psia	"	25 psia F_2	Ne/Xe-SF_6 @ 19/1, bright
77081901	50 psia	"	"	Ne/Xe-SF_6 @ 19/1, weak - roof leak coated optics
77081902-5	100 psia	"	"	Ne/Xe-SF_6 @ 19/1, not as bright as 1808
77082901-5	"	"	"	Ne/Xe @ 19/1, cleaned D. T. window, some brighter on first shot
77082906-7	"	"	"	Ne/Xe-SF_6 @ 19/1, brighter than shots since -01
77083001	"	"	"	Ne/Xe-SF_6 @ 29/1, cleaned tube with result much brighter
77083002	"	"	"	Ne/Xe-SF_6 @ 29/1, repeat with Spex side mirror detuned
77083003	"	"	"	Ne/Xe-SF_6 @ 29/1, realigned and cleaned windows, slightly brighter
77083004	"	"	"	Ne/Xe-SF_6 @ 30/1, much brighter - why?

Run Number	Driver	Metal	Oxidizer	Comments
77083005	50 psia	0	25 psia F_2	Ne/Xe-SF_6 @ 19/1, between brightness of 03 and 04
77083006	"	"	"	Ne/Xe-SF_6 @ 19/1, He-Ne absorption after reflected shock of ~ 1%
77083101	"	"	15 psia F_2	Ne/Xe-SF_6 @ 19/1, 450-650 nm mirrors
77083102	100 psia	"	25 psia F_2	Ne/Xe-SF_6 @ 29/1, single pass He-Ne attenuation is a "spikey" 1-5%
77083103	200 psia	"	"	Ne/Xe-SF_6 @ 78/2 torr, single pass He-Ne attenuation of 30% dropping to ~7%
77083104	100 psia	"	50 psia F_2	Ne/Xe-SF_6 @ 29/1, very bright, long λ spectrum only
77083105-6	"	"	"	Ne/Xe-SF_6 @ 29/1, repeats with tuned and detuned cavity
77083107	"	"	"	Ne/Xe-SF_6 @ 28/2, mirrors aligned, windows cleaned - brightest of day
77083108	"	"	"	Ne/Xe-SF_6 @ 26/4, much weaker
77090101	"	"	25 psia F_2	Ne/Xe-SF_6 @ 29/1, cleaned tube and nozzle, twice the intensity of 83001
77090102	"	"	50 psia F_2	Ne/Xe-SF_6 @ 28/2, double F_2 pressure increases intensity by approximately 1.4
77090103	"	"	"	Ar/Xe-SF_6 @ 28/2, Argon bath appears to increase intensity, $E_{\parallel}/E_{\perp} \cong 8$
77090104	"	"	"	Ar/Xe-SF_6 @ 28/2, repeat with detuned cavity
77090105	"	"	"	Ar/Xe @ 38/2, lower peak but about same integrated intensity as 28 torr
77090106	50 psia	"	"	Ar/Xe-SF_6 @ 16/1, lower intensity than 100 psi, but $E_{\parallel}/E_{\perp} \cong 10$
77090201	300 psi	"	"	Ar/Xe-SF_6 @ 96/4, XeF emission only during incident shock

Run Number	Driver	Injection Tank	Oxidizer	Comments
77090202	300 psia	Ar/Xe-SF_6 @ 192/8 torr	150 psia F_2	Very weak light emission
77090203	"	Ne/Xe-SF_6 @ 96/4 torr	"	Much less light than 201
77090204	100 psia	Ar/Xe-SF_6	15 psia F_2 + 185 psi Ar	Less intensity
77090205	"	"	50 psia F_2 + 100 psia Ar	Ar in F_2 decreased intensity by 2X and did not affect $E_\parallel/E_\perp$
77090206	"	"	50 psia F_2	Ar in F_2 decreased intensity by 2X and did not affect $E_\parallel/E_\perp$
77090601	"	"	"	Cleaned nozzle, very close to prior result, $E_\parallel/E_\perp = 7$
77090602	"	"	"	Detuned cavity by tilting both mirrors
77090603	"	"	"	Tuned cavity $E_\parallel/E_\perp = 7.7$
77090604	50 psia	Ar/Xe-SF_6 @ 15/1	"	Repeat of 090106, $E_\parallel/E_\perp = 6.6$ @ peak, 9.2 @ .3 ms later
77090605	"	"	"	Aperture on monochrometer side changed from .025-.008, now $E_\parallel/E_\perp = 15$
77090606	"	"	"	Detuned cavity
77090701	"	"	"	Prism added to rotate flow image @ Spex, moved optic axis closer to nozzle
77090702	"	"	"	Optical axis moved up to center of nozzle, still no notable change
77090703	"	"	"	Spex-side mirror out
77090704	"	"	"	Tuned cavity $E_\parallel/E_\perp \cong 8$
77090801	"	"	"	Detuned

Run Number	Driver	Injection Tank	Oxidizer	Comments
77090802	100 psia	Ar/Xe–SF_6 @ 28/2	50 psia F_2	Weaker than 801
77090803	"	"	"	Much brighter - why?
77090804	"	"	"	2 torr Argon back pressure in D.T., no notable change
77090805	"	"	"	~10 torr Argon back pressure in D.T., no notable change
77090806	"	"	25 psia F_2	Not as bright
77090901	"	"	50 psia F_2	Tube, tanks and nozzles cleaned, weak shot
77091201-4	"	"	"	Clean tube again makes much brighter shot, weaker in 03, 04
77091205	"	"	"	200 torr back pressure, little change
77091301	"	"	"	Optical axis moved 3-4 mm downstream, little change
77091302	"	Ar/Xe @ 23/2	"	New Xenon bottle, brighter (no SF_6)
77091303	"	"	"	Cavity detuned
77091304	"	"	"	Tuned, bright, $E_{\parallel}/E_{\perp} = 5.4$
77091305	"	"	"	Nozzle and Brewster windows aligned $E_{\parallel}/E_{\perp} = 8.6$
77091401-2	50 psia	Ar/Xe @ 15/1	"	Lost intensity, E ratio
77091403	"	"	"	Moved optical axis 2 mm downstream, intensity down
77091404	100 psia	Ar/Xe @ 28/2	"	Also very weak
77091501-5	"	"	"	Optical axis moved 3 mm toward nozzle, PIN diode meas.
77091601-3	"	"	"	More luminosity measurements with diode, filters
77091604	50 psia	Ar/Xe @ 15/1.5	"	F plate @ 2 cm
77091605	"	Ar/Xe @ 15/1	"	F plate @ 3 cm, Spex side mirror and lens removed
77091606	100 psia	Ar/Xe @ 28/2	"	F plate @ 4 cm, not as bright as it should be

Run Number	Driver	Injection Tank	Oxidizer	Comments
77091901	100 psia	Ar/Xe @ 28/2	50 psia F_2 + 100 psi Ar	F plate @ 5 cm
77091902	"	"	50 psia F_2	F plate @ 6 cm, about 60 torr Ar back pressure
77092001	"	"	"	F plate @ 2 cm, still not bright
77092002	50 psia	Ar/Xe @ 14/1	"	F plate @ 3 cm
77092003	100 psia	Ar/Xe @ 28/2	50 psi F_2 + 100 psia Ar	F plate @ 4 cm
77092004	"	"	0	F plate @ 5 cm, about 70 torr Ar back pressure
77092005	"	"	50 psia F_2	F plate @ 6 cm
77092006	200 psia	Ar/Xe @ 60/4	50 psia F_2 + 100 psia Ar	F plate @ 7 cm
77092101	50 psia	Ar/Xe @ 15/1	~29 psia F_2	
77092201	100 psia	Ar/Xe @ 38/2	50 psia F_2 + 150 Ar	F plate @ 2 cm
77092202	200 psia	Ar/Xe @ 76/4	"	F plate @ 3 cm
77092203	"	"	50 psia F_2	F plate @ 4 cm
77092204	"	"	"	F plate @ 5 cm
77092205	"	"	50 psia F_2 + 150 psia Ar	F plate @ 6 cm
77092601	50 psia	Ar/Xe @ 15/1	50 psia F_2	F plate @ 2 cm
77092602	"	"	50 psia F_2 + 150 psia Ar	F plate @ 3 cm
77092603	"	"	"	F plate @ 4 cm
77092801	"	Ar/COS @ 40/0.4	0	First shot of sulfur series, complex bundle of lines

Run Number	Driver	Injection Tank	Oxidizer	Comments
77092802-5	50 psia	Ar/COS	0	Varied Ar/COS ratio from .005 to .1, F plate
77092901-2	100 psia	Ar @ 80 torr	"	Before and after cleaning tube
77093001-2	"	Ar @ 200 torr	"	Complex line spectrum due to contamination, Al is strongest
77093003	"	Ar/COS @ 200/2	"	Diffuse background to lines due to COS
77093004	"	Ar @ 200 torr	"	Cleaned shock tube, incl NaOH wash, better but still many lines
77100301	"	Ar/COS @ 200/2	"	Al lines, AlO bands, plus diffuse background
77100302	"	Ar/H_2S @ 200/2	"	Al lines, no AlO bands, plus diffuse background - must be S_2
77100501-3	"	Ar @ 200 torr	"	Shock tube cleaned, incl dismantling nozzle end; Al + AlO notable
77100601	"	Ar/COS @ 198/2	"	Contaminant lines plus AlO plus background of diffuse bands, plus S_2 0,8 band (?)
77100602-4	50 psia	Ar @ 200 torr	"	Too slow, no light
77100605	"	Ar/COS @ 200/2	"	Too slow, no light
77100606	100 psia	"	"	Al plus AlO plus background
77100607	200 psia	Ar/COS @ 600/6	"	Bright banded continuum plus Al lines
77100701	"	Ar @ 600 torr	"	
77100702	"	Ar/COS @ 600/1.2	"	Comparing with 0607, light @ 3450Å ~ $[COS]^2$
77100703	100 psia	Ar/COS @ 320/1.2	"	Too slow, $t_{incident} - t_{reflected\ shock} \cong t_{ir} = .62$ ms

Run Number	Driver	Injection Tank	Oxidizer	Comments
77100704	200 psia	Ar @ 600 torr	0	Repeat of 01
77100705	100 psi	Ar/COS @ 270/1.2	"	t_{ir} = .62
77101001	"	Ar/COS @ 240/1.2	"	t_{ir} = .54
77101002	50 psia	Ar/COS @ 100/1.2	"	t_{ir} = .62
77101003	"	Ar/COS @ 70/1.2	"	t_{ir} = .57, appears that Argon pressure has little effect on light output for constant [COS], t_{ir}
77101004	200 psi	Ar/SF_6 @ 600/1.2	"	faint but for band @ 3590Å, degr. to blue, SF ?
77101005	"	Ar/COS @ 600/6	"	Good S_2 band structure, t_{ir} = .61
77101006	"	Ar/COS @ 800/6	"	Much weaker but still has distinct S_2 bands, t_{ir} = .66
77101101	"	Ar/COS @ 400/6	"	
77101102	" "	Ar/COS @ 600/6	"	
77101103-01	"	Ar/COS @ 540/60	"	Windows dirty
77101202	"	Ar/COS @ 400/60	"	Windows dirty, brighter, reversed bands
77101203	"	Ar/COS @ 240/60	"	Windows dirty, brighter, reversed bands
77101204	"	Ar/COS @ 600/6.5	"	Windows dirty, brighter, reversed bands

Run Number	Driver	Injection Tank	Oxidizer	Comments
77101205	200 psi	Ar @ 600 torr	"	Cleaned tube and windows, used CS_2 thrice, F plate @ 2 cm
77101206	"	Ar/COS @ 600/1.3	"	F plate @ 3 cm
77101301	"	Ar/COS @ 600/6	"	F plate @ 4 cm
77101302	"	Ar/COS @ 550/12	"	F plate @ 5 cm
77101303	"	Ar/COS @ 400/30	"	F plate @ 6 cm
77101304	"	Ar/COS @ 240/60	"	F plate @ 7 cm
77101305	"	Ar/COS @ 550/12	"	Cleaned all windows used
77101306	"	"	"	Cleaned all windows used, 340–370 nm mirror added, shows pass band
77101307	"	"	"	Two mirrors on, tuned
77101401	"	"	"	Repeat
77101402	"	"	"	Same but Spex end laser mirror out
77101403	"	"	"	Same with 0.1 ND filter
771014[illegible]4	100 psi	Ar/H_2S @ 210/12	"	
77101405	200 psi	Ar/H_2S @ 550/12	"	Brighter
77101406–7	"	Ar/H_2S/SF_6@ 550/10/2	"	Weaker, some lines gone

Run Number	Driver	Injection Tank	Oxidizer	Comments
77101801	200 psi	Ar/H_2S @ 600/6	0	Faint through 0.1 ND filter, $t_{ir} \cong .61$
77101802	"	Ar/SF_6 @ 600/6	"	Black through 0.1 ND filter, $t_{ir} = .63$
77101803	"	Ar/SF_6 @ 550/12	"	Very faint through 0.1 ND filter, $t_{ir} = .70$
77101804	"	Ar/SF_6 @ 400/12	"	Faint - no filter, $t_{ir} = .66$
77101805	"	Ar/SF_6 @ 200/12	"	Moderate 310–540 nm, $t_{ir} = .65$
77101806	"	Ar/SF_6 @ 400/6	"	Moderately bright with no filter, $t_{ir} = .60$
77101807	"	Ar/SF_6 @ 200/6	"	White with no filter, $t_{ir} = .58$
77101901	"	Ar/SF_6 @ 100/6	"	White in 320–500 nm with 28% filter, $t_{ir} = .47$
77101902	"	6 torr SF_6, 200 Argon	"	Shock tube emission brighter, Spex weaker, $t_{ir} = .59$
77101903	"	6 torr SF_6, 150 Argon	"	$t_{ir} = .54$
77101904	"	3 torr SF_6, 400 Ar	"	$t_{ir} = .60$, about half as bright as 1902
77101905	"	6 torr H_2S, 500 Ar	"	$t_{ir} = .60$, notably different character of emission time
77101906	"	12 torr H_2S, 450 Ar	"	$t_{ir} = .62$, same light level from ST, more from nozzle

Run Number	Driver	Injection Tank	Oxidizer	Comments
77101907	200 psia	12 torr H_2S, 300 Ar	0	$t_{ir} \cong .57$, brighter Spex
77101908	"	6 torr SF_6, 150 Ar	"	$t_{ir} = .49$, 360 nm band mirrors
77102001	"	"	"	$t_{ir} = .56$, notably less light
77102002	"	"	"	$t_{ir} = .51$, bright
77102003	"	"	"	$t_{ir} = .56$, still bright
77102004	"	12 torr SF_6, 50 Ar	"	$t_{ir} = .60$, very weak emission
77102005	"	12 torr SF_6, no Ar	"	$t_{ir} = .55$, dark Spex, < 1/10 light of 2001
77102006	"	6 torr SF_6, 150 Ar	"	$t_{ir} = .56$
77102007	"	"	"	$t_{ir} = .57$ - same but SF_6 from lecture bottle, same results
77102008	"	6 torr SF_6, 100 Ar	"	$t_{ir} = .53$, F plate @ 2 cm
77102009	"	6 torr SF_6, 150 Ar	"	$t_{ir} = .53$, F plate @ 3 cm
77102010	"	6 torr SF_6, 200 Ar	"	$t_{ir} = .60$, F plate @ 3 cm, ~60% of light of prior shot
77102101	"	6 torr SF_6, 400 Ar	"	$t_{ir} = .62$, F plate @ 5 cm, ~half light of prior shot
77102102-3	"	3 torr SF_6, 400 Ar	"	$t_{ir} = .57$, F plate @ 6 cm, strong light from ST, nozzle like 2004
77102104	"	1 torr SF_6, 600 Ar	"	$t_{ir} = .61$, lines dominate spectrum, weak bands in 300 nm region

Run Number	Driver	Injection Tank	Oxidizer	Comments
77102401-3	"	600 Ar only	0	Shock nozzle plugged to get p(t) data, t_{ir} = .61, .60
77102402	"	1000 Ar	"	t_{ir} = .71
77102404-01	"	600 Ar	"	Beam deflection tests using 2-axis sensor
77102702	"	6 torr COS, 600 Ar	"	t_{ir} = .61
77102703	100 psia	6 torr COS, 290 Ar	"	t_{ir} = .64 - intensity halved
77102704	50 psia	6 torr COS, 120 Ar	"	t_{ir} = .69 - intensity halved
77102705	200 psia	600 torr Ar	"	Beam deflection measurement
77102706	50 psia	12 torr COS	"	Very faint, t_{ir} = .56 ms
77102707	200 psia	12 torr COS, 50 Ar	"	t_{ir} = .66, faint broad band 330-500 nm (shifted to red)
77102708	50 psi	6 torr COS, 50 Ar	"	t_{ir} = .59, .4 volts peak from ST
77102801	"	"	"	t_{ir} = .60
77102802	"	6 torr COS, 30 Ar	"	t_{ir} = .55
77102803-02	"	50 torr Ar	"	Deflection measurement
77103103	"	6 torr COS, 30 Ar	"	Put on 360 nm band mirrors, $\parallel/\perp$ = 15 mv/29 mv
77103104	"	"	"	Realigned, $\parallel/\perp$ = 25 mv/24 mv
77103105	"	"	"	Rotated each mirror to band cavity $\parallel/\perp$ = 30/26
77103106	"	"	"	Repeat with cleaned and realigned, $\parallel/\perp$ = 24/24

Run Number	Driver	Injection Tank	Oxidizer	Comments
77103107	50 psia	6 torr COS, 30 Ar	0	Repeat with detuned cavity, $\parallel/\perp$ = 28 mv/28 mv
77103108	"	"	"	Spectrum on Polaroid
77110101	"	"	"	Repeat of 3108, but windows coated
77110102	"	"	"	Repeat with 0.1 ND filter
77110103	"	"	"	Repeat, 1 mm slit upper
77110301	"	"	"	450–650 B.B. mirrors on, set @ 4790Å (3,18 band), t_{ir} = .52
77110302	"	"	"	Cavity blocked - t_{ir} = .52
77110303	"	"	"	Cleaned windows, repeat 0301 - looks same as 0302, t_{ir} = .52
77110304	"	"	"	Dump tank diaphragm broken (?) - t_{ir} = .43
77110305	"	"	"	Mirrors rotated to account for path curvature due to $d\rho/dx$ 1 KV on PMT t_{ir} = .51
77110306	"	6 torr COS, 50 Ar	"	t_{ir} = .55, nearly as bright as prior shot
77110307	"	6 torr COS, 20 Ar	"	Brightest of series, t_{ir} = .49
77110308	"	6 torr COS, 30 Ar	"	t_{ir} = .51, added .09" ø collimation aperture
77110309	"	"	"	Realigned, 800 V in PMT - this shot only
77110401	"	"	"	New 400–500 nm laser mirrors, set @ 479 nm, beam @ nozzle throat
77110402–4	"	"	"	800 V on PMT, first shot very dim, all have too little nozzle $\parallel - \perp$ signal

Run Number	Driver	Injection Tank	Oxidizer	Comments
77110405-6	"	6 torr COS, 30 Ar	0	1000 V on PMT, signal with mirror approximately 3X that with blocked cavity, $\parallel/\perp$ gain = 1.8
77110407-8	"	"	"	Found misaligned, repeated, found no gain
77110409-10	"	"	"	By rotating mirror to accommodate curved path increased $\parallel/\perp$ quotient to 1.5
77110411-12	"	6 torr COS, 50 Ar	"	No observed increase in $\parallel/\perp$, t_{ir} = .57
77110413	"	3 torr COS, 50 Ar	"	t_{ir} = .53, 1/4 the light of the 6 torr case, in accord with square law
77110414	100 psia	10 torr COS, 70 Ar	"	t_{ir} = .51, 7/2-2.6 x the 6 torr light, square law predicts 2.8
77110415	"	"	"	t_{ir} = .51, path blocked
77110701-5	"	10 torr COS, 100 Ar	"	t_{ir} = .49-.54 (first was only 70 torr), #4-5 show $\parallel/\perp$ increased by 1.7
77110706-7	"	10 torr COS, 200 Ar	"	t_{ir} = .60, .59, $\parallel/\perp$ showed no increase
77110708	"	10 torr COS, 300 Ar	"	t_{ir} = .66, very weak luminescence
77110709-10	"	20 torr COS, 100 Ar	"	t_{ir} = .58, cavity tuned for no flow, first shot blocked
77110711	"	"	"	Cavity off set for curved path, $\parallel/\perp$ ratio increased by 1/4
77110712-15	"	"	"	Deflection measures ~ 1.8 m Radian
77110801	"	"	"	Spex side laser mirror out, spectrum dense from 360-500 nm
77110802-3	"	"	"	Cleaned, aligned, and rotated mirrors, $\parallel/\perp$ ratio increased 15% over blocked path

Run Number	Driver	Injection Tank	Oxidizer	Comments
77110804	100 psia	20 torr COS, 100 Neon	"	t_{ir} = .49 (equivalent to .69 in Argon), dim
77110805	80 psia	"	"	t_{ir} = .53, dimmer!
77110806	100 psia	20 torr COS, 100 N_2	"	t_{ir} = .60, equivalent to .92 in Argon, dim
77110807	150 psia	"	"	t_{ir} = .54
77110808	"	13 torr COS, 67 N_2	"	t_{ir} = .48, equivalent to .74 in Argon
77110809	200 psia	"	"	Very strong emission from incident shock, nozzle t_{ir} = .46
77110901	150 psia	6.7 torr COS 67 N_2	"	Spectrum, very similar to that using Argon as carrier
77110902-4	"	6.7 torr COS, 67 CO	"	Spectrum identical to that with N_2 as carrier, $t_{ir} \cong .42$ ms
77110905	100 psia	260 torr Ar	"	
77110906	150 psia	20 torr COS, 100 N_e	"	t_{ir} = .50 (equivalent to .71 in Argon), dim
77110907	200 psia	"	"	t_{ir} = .40 (equivalent to .56 in Argon), bright, but with uncleaned windows
77110908	80 psia	20 torr COS, 100 Kr	"	t_{ir} = .85 (equivalent to .57 for Argon), lower P and dimmer than prior Ne Shot
77111001	100 psia	"	"	t_{ir} = .8, brighter, no scope info
77111002	"	"	"	Windows cleaned, no scope info, bright spectrum
77111003	"	10 torr COS, 50 Ne	"	Laser windows (400-500 nm)on; tuned, no scope info
77111004	200 psia	20 torr COS, 100 Ne	"	

Run Number	Driver	Injection Tank	Oxidizer	Comments
77111005	200 psia	20 torr COS, 100 Ne	0	Spex side window off, bright spectrum - best shot with scopes on AC input
77111006	"	"	"	D.T. diaphragm only half opened
77111007-8	"	"	"	Ratio of $\parallel/\perp$ ratios - open vs blocked path - is .96 - no effect, t_{ir} = .38
77111009	"	20 torr COS, 200 Ne	"	More light from S.T., dimmer from nozzle
77111010	"	20 torr COS, 50 Ne	"	Brightest on incident shock, less nozzle light than -08
77111101	"	10 torr COS, 200 Ne	"	t_{ir} = .36
77111102	"	10 torr COS, 100 Ne	"	t_{ir} = .36, brighter than prior shot
77111401	"	10 torr COS, 50 Ne	"	t_{ir} = .35, less S.T. light than 1102, about same from nozzle
77111402	"	10 torr COS, 100 Ne	"	Cleaned Brewster windows, tuned, with no evident change in $\parallel/\perp$ ratio
77111403	"	"	"	Same with path blocked, ratio of $\parallel/\perp$ ratios ≅ 1.09
77111404-6	"	5 torr COS, 100 Ne	"	Blocked and open, ratio of $\parallel/\perp$ ratios = 1.0
77111407	"	"	"	Moved optical path from A* to 2 mm downstream, $\parallel/\perp$ = 1.16
77111408-9	"	"	"	Reduced height of $\parallel, \perp$ slits to ~1/2 cm, $\parallel/\perp$ = 1.25; down to .82 path blocked
77111410-11	"	"	"	Further reduced height of $\parallel, \perp$ slits to ~2 m, RR = ($\parallel/\perp$/open/ $\parallel/\perp$/ blocked) = 1.0/.78
77111412	"	5 torr COS, ~300 Ne	"	Loading error, t_{ir} = .40, very dim

Run Number	Driver	Injection Tank	Oxidizer	Comments
77111501-2	200 psia	5 torr COS, 100 Ne	0	Deflection measures 1.6 mR → 2 mR
77111503-4	"	"	"	Tuned with thimbles 0.4 turn each from zero flow peak, RR = 2.95/.8 = 3.69 (ratio of ratios ≡ RR)
77111505	"	"	"	Cleaned windows and realigned, RR = 1.68/0.8 = 2.1
77111506-7	"	"	"	Doubled window purge, RR = 2.9, 2.4
77111508	"	"	"	Turned windows so now 1.8 mR beam bend is compensated for, RR = 2.2
77111509-11	"	"	"	Mounted Kistler gauge in window mount sleeve, trace off scale
77111601-4	"	"	"	Kistler shows violent pressure fluctuation, due to nozzle, not sweep gas
77111605-04	"	"	"	Slit nozzle, aligned cavity just beyond A*, 400-500 nm mirrors, timing problems
77112101	50 psia	16 torr Ar	"	"New" tube nozzle, He-Ne beam deflection is ~0.2 mR, -0.2-0.4 mR with only oxidizer flow of 100 psia
77112102	100 psia	30 torr Ar	150 psi Ar	Deflection of 0.4 mR
77112103-4	200 psia	60 torr Ar	0	1/2-2 mR deflection
77112105	50 psia	16 torr Ar	"	~ 0.2 mR deflection, last shot with He-Ne beam 8mm downstream
77112106-8	200 psia	60 torr Ar	"	Moved to 2mm station, 0.1-0.5 mR deflection
77112201	50 psia	16 torr Ar	"	360 nm mirrors (same as used for XeF before), tuned, MC @ 351 nm, dark
77112202	"	1/15 torr Xe/Ar	50 psi F_2	Bright XeF band
77112303	"	1/20 torr Xe/Ar	"	Not quite as bright

Run Number	Driver	Injection Tank	Oxidizer	Comments
77112801-3	50 psia	1/15 torr Xe/Ar	50 psi F_2	Path blocked
77112804-7	"	"	"	Cavity tuned to no flow, cleaned, RR = 2.2, 2.6
77112808	"	"	"	Still .008 aperture before polarizing prism, RR - 2.2, 3.0
77112809	"	"	"	Path blocked
77112810	"	"	"	Bad shot - mirror had been inadvertently moved
77112811	"	"	"	$\parallel$ path only blocked
77112901-2	"	"	"	$\parallel, \perp$ lines switched to (fast response) amplifier box, $\parallel, \perp \cong 1$
77112903	"	"	"	Took off second dust cap, $\parallel, \perp = 2$ to 3
77112904	"	"	"	Path blocked, $\parallel / \perp = 0.6$
77112905	"	"	"	$\parallel, \perp > 4$, RR > 6.7 (after retuning)
77112906	"	"	"	Path blocked, $\parallel / \perp \sim 1.8$??
77112907	"		"	Moved .008 sq. in. aperture to between laser and 45° mirrors, blocked
77112908-10	"	"	"	#2 scope triggered too early on 08, RR ≅ 7
77113001-2	"	"	"	Cleaned tube $\parallel / \perp \cong 10$
77113003	"	"	"	Path blocked $\parallel / \perp \cong 1.8$, RR ≅ 6
77113004	"	"	"	$\parallel / \perp \cong 12$
77113005	"	"	25 psia F_2	Path blocked
77113006	"	"	50 psia F_2	Path blocked, $\parallel / \perp = 1.7$
77113007	"	"	"	$\parallel / \perp \sim 20$, so RR = 12
77113008-10	"	"	"	Mirror rotated by 0.4 mR, $\parallel / \perp = 10$ @ peak signal, 25 later, max RR ≅ 15

Run Number	Driver	Injection Tank	Oxidizer	Comments
77113011	50 psia	1/15 torr Xe/Ar	50 psia F_2	Rotated mirror another 0.4 mR, appears to have detuned
77120101	"	"	"	Rotated mirror back to midway between 3007 and 3009
771201-0503	"	"	"	Series on mirror turning - see plot
77120504-603	"	"	"	Same mirrors, no Brewster windows, $\parallel/\perp < 1$
77120604-5	"	"	"	Brewster windows and lansing mounts, $\parallel/\perp \cong 13$
77120606	"	"	"	Blocked path, $\parallel/\perp = 3$
77120607-8	"	"	"	$\parallel/\perp = 15,16$
77120609-0910	"	"	"	Second mirror position series - see plot
77121201	100 psia	200 torr Ar	0	Background check, switched to slit nozzle, 2 mm station
77121202-4	"	Ar/COS @ 200/2	"	No mirror on Spex side, band spectra
77121205	"	Ar/COS @ 200/5	"	No mirror on Spex side, band spectra
77121206	150 psia	CO_2/COS @ 200/2	"	Black
77121207	200 psia	CO_2/COS @ 50/2	"	Black
77121208	300 psia	Ar/CO_2/COS @ 30/20/2	"	AlO bands
77121209-10	"	Ar/CO_2/COS @ 40/10/2	"	AlO, diffuse S_2 band
77121301	"	Ar/CO_2 @ 40/10	"	Brighter, AlO plus continuum

Run Number	Driver	Injection Tank	Oxidizer	Comments
77121302	100 psia	Ar/COS @ 200/2	0	1-F plate, 2 cm, very faint diffuse spectrum, bad plate?
77121303	"	Ar/COS @ 200/5	"	1-F plate, 3 cm, very faint diffuse spectrum, bad plate?
77121304	"	Ar/N_2/COS @ 180/20/2	"	1-F plate, 4 cm, very faint diffuse spectrum, bad plate?
77121305	"	N_2/COS @ 200/2	"	1-F plate, 5 cm, very faint diffuse spectrum, bad plate?
77121306	200 psia	N_2/COS @ 200/2	"	1-F plate, 6 cm, very faint diffuse spectrum, bad plate?
77121401	100 psia	Ar/COS @ 200/2	"	103-F plate, 2 cm, too faint
77121402	"	Ar/COS @ 200/5	"	103-F plate, 3 cm, too faint
77121403	"	Ar/N_2/COS @ 180/20/2	"	103-F plate, 4 cm, too faint
77121501	"	N_2/COS @ 200/2	"	103-F plate, 5 cm, too faint
77121502	200 psia	N_2/COS @ 200/2	"	103-F plate, 6 cm, too faint
77121503	100 psia	Ar/COS @ 200/2	"	1-F plate, 2 cm
77121504	"	Ar/COS @ 200/5	"	1-F plate, 3 cm
77121505	"	Ar/N_2/COS @ 80/20/2	"	1-F plate, 4 cm

Run Number	Driver	Injection Tank	Oxidizer	Comments
77121506	100 psia	N_2/COS @ 200/2	0	1-F plate, 5 cm
77121507	200 psia	N_2/COS @ 200/2	"	1-F plate, 6 cm
77121601	100 psia	Ar/COS @ 200/5	"	
77121602	"	Ar/N_2/COS @ 180/20/5	"	No notable difference in spectrum (on Polaroid)
77121603	"	N_2/COS @ 200/5	"	Black
77121604	"	Ar/C_2H_4/COS @ 100/5/5	"	Faint bands, not S_2
77121605	"	Ar/COS/C_2H_4 @ 200/5/1	"	Weaker than 1601
77122101	"	200 torr Ar	"	Lines only
77122102	"	Ar/SiH_4/SF_6 @ 200/1/1	"	SiF A-X, B-X, weak S_2 bands
77122201	"	Ar/SiH_4/SF_6 @ 200/2/2	"	Weaker SiF, stronger S_2
77122202	"	Ar/SiH_4/SF_6 @ 150/5/5	"	S_2 stronger but still weak, SiF A-X has become diffuse
77122203	"	Ar/SiH_4/SF_6 @ 200/2/2	"	1-F plate @ 2 cm
77122204	"	Ar/COS @ 200/5	"	1-F plate @ 3 cm
77122205	"	Ar/COS/C_2H_4 @ 200/5/1	"	1-F plate @ 4 cm

Run Number	Driver	Injection Tank	Oxidizer	Comments
77122206	100 psia	Ar/COS/C_2H_4 @ 180/5/2	0	1-F plate @ 5 cm
77122207	"	Ar/COS @ 180/10	"	1-F plate @ 6 cm, t_{ir} = .57
77122208	"	Ar/COS @ 150/20	"	1-F plate @ 7 cm
78010301	"	Ar/COS @ 200/5	"	Polaroid, t_{ir} = .57
780105xx	-	-	-	Standard lamp exposed plate
78010501	100 psia	Ar/COS @ 100/5	0	Window epoxied to inside of Brewster window tube - Spex side
78010502	"	Ar/COS @ 200/10	"	Still with blocked Brewster window tube, t_{ir} = .59
78010503	"	Ar/COS @ 170/20	"	Still with blocked Brewster window tube, t_{ir} = .60
78010001-2	"	Ar/COS @ 120/20	"	Still with blocked Brewster window tube, t_{ir} = .58, .57
78011003-4	"	"	"	Removed blocking window; spectrum brighter, more @ short λ
78020701-2	"	"	"	t_{ir} = .56; forgot to add 28% ND filter so hard to compare spectrum
78020703	"	Ar/COS @ 200/10	"	Brighter than 010502, t_{ir} = .58
78020704	"	Ar/COS/N_2O @ 190/10/10	"	Polaroid - N_2 appeared to extend spectrum, t_{ir} = .55
78021001	"	Ar/COS @ 200/10	"	IF plate @ 2 cm, t_{ir} = .58

Run Number	Driver	Injection Tank	Oxidizer	Comments
78021002	100 psia	Ar/COS/N_2O @ 190/10/10	0	IF plate @ 3 cm, t_{ir} = .58
78021003-4	"	Ar/COS @ 200/10	"	IF plate @ 4 cm, t_{ir} = .58, .58
78021005-6	"	Ar/COS/N_2O @ 190/10/10	"	IF plate @ 5 cm
78021301	"	Ar @ 200 torr	"	t_{ir} = .56
78021302	"	Ar @ 400 torr	"	t_{ir} = .68 - black
78021303	"	Ar/$C_2F_4S_2$ @ 400/1	"	t_{ir} = .78 - black
78021401	"	Ar/$C_2F_4S_2$ @ 200/1	"	t_{ir} = .54; lines, weak bands
78021402	"	Ar/$C_sF_4S_2$ @ 200/2	"	t_{ir} = .56, bands stronger, include S_2, CN
78021403	"	Ar/$C_2F_4S_2$ @ 300/2	"	t_{ir} = .62, weak lines, lost bands
78021404	"	Ar/$C_2F_4S_2$ @ 150/2	"	t_{ir} = .52, like 02 but brighter, S_2 B-X is near a continuum
78021405	"	Ar/$C_2F_4S_2$ @ 100/2	"	t_{ir} = .49, brighter yet
78021406	"	Ar/$C_2F_4S_2$ @ 50/2	"	t_{ir} = .46 - still brighter
78021501	"	"	"	Maladjusted mirror and lens
78021502	"	Ar/$C_2F_4S_2$ @ 20/2	"	Very bright but image still not right
78021601-4	"	Ar/COS @ @ 200/10	"	Adjusting optics, no D. T. diaphragm last three; added .049 sq. in. aperture

Run Number	Driver	Injection Tank	Oxidizer	Comments
78021701-2	100 psia	Ar/COS @ 200/10	0	Without and with D. T. diaphragm, t_{ir} = .47, .56
78021703	"	Ar/COS/NO @ 190/10/10	"	NO appears to quench long λ side of spectrum, t_{ir} = .57
78021704	"	Ar/COS @ 200/10	"	IF plate @ 2 cm; these very faint on plate, traces yield little info
78021705	"	Ar/COS/NO @ 190/10/10	"	IF plate @ 3 cm; these very faint on plate, traces yield little info
78021706-7	"	"	"	IF plate @ 4 cm; these very faint on plate, traces yield little info
78022101	"	Ar/COS @ 400/20	"	t_{ir} = .57
78022102	"	Ar @ 200 torr	"	t_{ir} = .53, black but for Al lines
78022103	"	Ar/$(CH_3)_2S$ @ 200/1	"	t_{ir} = .54, black but for Al lines
78022201	"	Ar/COS @ 200/1	"	t_{ir} = .48, no diaphragm in D. T.
78022202	"	Ar/COS @ 400/10	"	t_{ir} = .55, no diaphragm in D. T.
78022203	"	Ar/COS @ 380/20	"	t_{ir} = .57, no diaphragm in D. T., spectrum like 01; no diaphragm is okay
78022204	"	Ar/$(CH_3)_2S$ @ 200/2	"	t_{ir} = .58, black; later found air leak due to cracked cap
78022205	"	Ar/$(CH_3)_2S$ @ 100/2	"	t_{ir} = .52, black; later found air leak due to cracked cap
78022301	"	Ar/$(CH_3)_2S$ @ 100/10	"	t_{ir} = .56, black; later found air leak due to cracked cap

Run Number	Driver	Injection Tank	Oxidizer	Comments
78022302	100 psia	$Ar(CH_3)_2S$ @ 100/10	0	t_{ir} = .54, black
78022303	"	$Ar/(CH_3)_2S$ @ 50/10	"	t_{ir} = .52, black; between these shots found cracked cap and replaced
78022304	"	$Ar/(CH_3)_2S$ @ 100/10	"	t_{ir} = .60, black; between these shots found cracked cap and replaced
78022401	"	Ar/COS @ 100/10	"	t_{ir} = .51 - moderately bright spectrum, conclude no light from $(CH_3)_2S$
78022402	"	$Ar/(CH_3)_2S$ @ 100/1	"	t_{ir} = .50, lines, very weak CN bands
78030301	"	$Ar/(CH_3)_2S_2$ @ 400/11	"	t_{ir} = .78, black
78030302	"	$Ar/(CH_3)_2S_2$ @ 100/10	"	t_{ir} = .62, black, Dimethyl disulphide must be dissociating infrared from t_{ir}
78030303	"	$Ar/(CH_3)_2S_2$ @ 100/2	"	t_{ir} = .45, line spectra, mainly Al
78030304	"	$Ar/(CH_3)_2S_2$ @ 50/5	"	t_{ir} = .55, weak continuum centered about 4300Å
78030305	200 psia	$Ar/(CH_3)_2S_2$ @ 50/5	"	$t_{ir} \cong .43$ - black
				Never got S_2 bands from $(CH_3)_2S_2$
78030601	100 psia	Ar/COS @ 200/10	"	t_{ir} = .57; moderately bright bands using .049 sq aperture Spex input
78030602	"	"	"	Same but aperture out - much brighter spectrum
78030603	"	"	"	Same but with 28% ND filter, still very bright

Run Number	Driver	Injection Tank	Oxidizer	Comments
78030701	100 psia	Ar/COS @ 200/10	0	Passing only downstream light by use of vertical card edge, moderately bright
78030702	"	Ar/COS @ 120/20	"	t_{ir} = .56, moderately bright, diffuse
78030703	200 psia	Ar/COS @ 400/10	"	t_{ir} = .53, brighter
78030704	"	Ar/COS @ 500/10	"	t_{ir} = .57, still brighter than 02
78030705	"	Ar/COS @ 520/5	"	t_{ir} = .60, moderately bright, sharp
78030706	"	Ar/COS @ 400/20	"	t_{ir} = .57, bright
78030801	"	Ar/COS @ 100/50	"	t_{ir} = .53, bright and centered @ 4100Å
78030802	"	Ar/COS @ 200/40	"	t_{ir} = .55, bright - shows absorption lines
78030803	"	Ar/COS @ 300/30	"	t_{ir} = .55
78030804	"	Ar/COS/N_2 @ 300/30/3	"	t_{ir} = .55 - not notably different in appearance from prior shot
78030805	"	Ar/COS/N_2 @ 300/30/3	"	t_{ir} = .55, some minor changes from prior spectrum
78030806	"	Ar/COS/N_2 @ 260/30/10	"	t_{ir} = .53, again, similar to shot 0803
78030901	"	Ar/COS @ 400/20	"	t_{ir} = .56, I-O plate @ 2 cm

Run Number	Driver	Injection Tank	Oxidizer	Comments
78030902	200 psia	Ar/COS/N_2O @ 380/20/2	"	t_{ir} = .54, I-O plate @ 3 cm
78030903	"	Ar/COS/N_2O @ 380/20/10	"	t_{ir} = .56, I-O plate @ 4 cm
78030904	"	Ar/COS/NO @ 395/20/2	"	t_{ir} = .56, I-O plate @ 5 cm
78030905	"	Ar/COS/NO @ 380/20/10	"	t_{ir} = .56, I-O plate @ 6 cm
78030906	"	Ar/COS @ 400/20	"	t_{ir} = .56, I-O plate @ 7 cm
78031101	"	"	"	t_{ir} = .58, I-O plate @ 2 cm
78031102	"	Ar/COS/O_2 @ 345/20/2	"	I-O plate @ 3 cm
78031103	"	Ar/COS/O_2 @ 380/70/10	"	I-O plate @ 4 cm
78031401	100 psi	Ar/COS @ 200/10	"	I-O plate @ 5 cm
78031402	"	Ar/COS/O_2 @ 190/10/10	"	I-O plate @ 6 cm
78031403	"	Ar/COS/O_2 @ 195/10/3	"	I-O plate @ 7 cm
78031404	"	Ar/SiH_4/SF_6 @ 200/2/2	"	Weak spectrum, some B-X S_2, some SiF
78031405	"	Ar/SiH_4/SF_6 @ 400/2/2	"	Black
78031406	"	Ar/SiH_4/SF_6 @ 200/5/5	"	Stronger - but still weak - S_2 spectrum

Run Number	Driver	Injection Tank	Oxidizer	Comments
78031407	100 psia	$Ar/SiH_4/SF_6$ @ 400/5/5	0	Black
78032001	"	Ar/COS @ 210/5	"	I–O plate @ 2 cm, COS partial pressure series holding t_{ir}
78032002	"	Ar/COS @ 200/10	"	I–O plate @ 3 cm, COS partial pressure series holding t_{ir}
78032003	"	Ar/COS @ 120/20	"	I–O plate @ 4 cm, COS partial pressure series holding t_{ir}
78032004	"	Ar/COS @ 40/30	"	I–O plate @ 5 cm, COS partial pressure series holding t_{ir}
78032005	200 psia	Ar/COS @ 480/5	"	I–O plate @ 6 cm, COS partial pressure series holding t_{ir}
78032006	"	Ar/COS @ 470/10	"	I–O plate @ 7 cm, COS partial pressure series holding t_{ir}
78032101	"	"	"	New I–O plate @ 2 cm, COS partial pressure series holding t_{ir}
78032102	"	Ar/COS @ 380/20	"	New I–O plate @ 3 cm, COS partial pressure series holding t_{ir}
78032103	"	Ar/COS @ 310/30	"	New I–O plate @ 4 cm, COS partial pressure series holding t_{ir}
78032104	"	Ar/COS @ 210/40	"	New I–O plate @ 5 cm, COS partial pressure series holding t_{ir}
78032105	"	Ar/COS @ 150/50	"	New I–O plate @ 6 cm, COS partial pressure series holding t_{ir}
78032106	"	Ar/COS @ 480/5	"	New I–O plate @ 7 cm, COS partial pressure series holding t_{ir}
78032201	100 psia	$Ar/SiH_4/SF_6$	"	New I–O plate @ 2 cm, SiH_4/SF_6 series

Run Number	Driver	Injection Tank	Oxidizer	Comments
78032202	100 psia	$Ar/SiH_4/SF_6$ @ 150/5/5	0	New I-O plate @ 3 cm, SiH_4/SF_6 series
78032203	"	$Ar/SiH_4/SF_6$ @ 100/10/10	"	New I-O plate @ 4 cm, SiH_4/SF_6 series
78032204	200 psia	$Ar/SiH_4/SF_6$ @ 400/5/5	"	New I-O plate @ 5 cm
78032205	"	$Ar/SiH_4/SF_6$ @ 300/5/5	"	New I-O plate @ 6 cm
78032206	"	$Ar/SiH_4/SF_6$ @ 200/10/10	"	New I-O plate @ 7 cm
78032701	100 psia	Ar/COS @ 210/5	"	On Polaroid - adjusting Spex lens
78032702	"	"	"	Adjusting Spex lens
78032703	"	"	"	Adjusting Spex lens
78032704	"	"	"	Adjusting Spex lens
78032801	"	"	"	I-O plate @ 2 cm, t_{ir} = .56 ms, repeat of COS series
78032802	"	Ar/COS @ 200/10	"	I-O plate @ 3 cm, t_{ir} = .58 ms, repeat of COS series
78032803	"	Ar/COS @ 120/20	"	I-O plate @ 4 cm, t_{ir} = .61 ms, repeat of COS series
78032804	"	Ar/COS @ 40/30	"	I-O plate @ 5 cm, t_{ir} = .57 ms, repeat of COS series
78032805	200 psia	Ar/COS @ 480/5	"	I-O plate @ 6 cm, t_{ir} = .54 ms, repeat of COS series
78032806	"	Ar/COS @ 470/10	"	I-O plate @ 7 cm, t_{ir} = .57 ms, repeat of COS series

Run Number	Driver	Injection Tank	Oxidizer	Comments
78033001	200 psia	Ar/COS @ 470/10	0	New I–O plate @ 2 cm, t_{ir} = .56
78033002	"	Ar/COS @ 380/20	"	New I–O plate @ 3 cm, t_{ir} = .59
78033101	"	Ar/COS @ 310/30	"	New I–O plate @ 4 cm, t_{ir} = .57
78033102	"	Ar/COS @ 210/40	"	New I–O plate @ 5 cm, t_{ir} = .51
78033103	"	Ar/COS @ 150/50	"	I–O plate @ 6 cm, t_{ir} = .56
78033104	"	Ar/COS @ 480/5	"	I–O plate @ 7 cm, t_{ir} = .56
78040401	150 psia	$Ar/SF_6/SiH_4$ @ 200/5/5	"	New I–O plate @ 2 cm, t_{ir} = .58
78040402	"	$Ar/SF_6/SiH_4$ @ 160/5/5	"	New I–O plate @ 3 cm, t_{ir} = .57
78040403	"	$Ar/SF_6/SiH_4$ @ 110/10/10	"	New I–O plate @ 4 cm, t_{ir} = .55
78040404	200 psia	$Ar/SF_6/SiH_4$ @ 440/5/5	"	New I–O plate @ 5 cm, t_{ir} = .56
78040405	"	$Ar/SF_6/SiH_4$ @ 350/5/5	"	New I–O plate @ 6 cm, t_{ir} = .54
78040406	"	$Ar/SF_6/SiH_4$ @ 240/10/10	"	New I–O plate @ 7 cm, t_{ir} = .54
78040601-2	"	Ar/COS @ 380/20	"	No Spex result

Run Number	Driver	Injection Tank	Oxidizer	Comments
78040603	200 psia	Ar/COS @ 380/20	0	No filter, very bright on Polaroid
78040604	"	"	"	26% N.D. filter (also for next 3 shots)
78040605	"	"	"	Shot @ 0.3 torr, not as bright
78040701-2	300 psia	"	"	t_{ir} = .53, brighter than 200 psi shot (0604)
78040703	"	"	"	Brightest @ ~ 4100Å
78040704	200 psi	Ar/COS @ 210/40	"	Not as bright as prior shot, especially @ short λ
78040705	300 psi	"	"	Brighter - but no spectrum
78041701	200 psi	ST w/Ar/COS @ 127/6.7	"	Plug placed in S.T. between injection tank and nozzle, mirror misaligned
78041702	"	"	"	More line than band structure
78041703-1801	"	ST w/Ar/COS @ 50/5	"	Dense line structure
78041802-1904	"	ST w/Ar/COS @ 100/5, 200/5, 50/5	"	
78042001	"	ST w/Ar/COS @ 50/5	"	Lines and continuum
78042002	"	ST w/Ar/COS @ 80/5	"	Bands now evident, less lines
78042003	100 psia	"	"	Very faint continuum @ ~ 4300Å
78042004	200 psia	ST w/Ar/COS @ 100/5	"	
78042005	"	ST w/Ar/COS @ 200/5	"	Brighter than -03 even with 26% N.D. filter

Run Number	Driver	Injection Tank	Oxidizer	Comments
78042006	200 psia	ST w/Ar/COS @ 200/5	0	Filter off, distinct (diffuse) bands
78042007	"	ST w/Ar/COS @ 200/2	"	Bands as bright and sharper
78042008	"	ST w/Ar/COS @ 200/1	"	Similar to -07
78042101	"	ST w/Ar/COS @ 200/0	"	Only lines
78042102	"	ST w/Ar/COS @ 127/6.7	"	Diffuse bands
78042103	"	ST w/Ar/COS @ 127/6.2	"	Moved plug back 3" from nozzle end, lines and continuum only!
78042104	"	Ar/COS @ 380/20	"	Bright lines and continuum - back to prior configuration
78042501	150 psia	CO @ 180 torr	"	Black spectrum (on Polaroid); #2 type nozzle
78042502	"	"	"	Plus 200 psi N_2O
78042503	"	CO @ 180; 0.2 g Mg	200 psi N_2O	Only solitary weak line @ ~ 4570, t_{ir} = .53 ms
78042504	"	"	"	Lots of Mg lines, but prior one gone, band head @ 3495, dgr bl
78042505	"	No CO; 0.2 g Mg	"	This in error, should have had Ar for CO
78042601	"	180 torr CO; 0.2 g Mg	"	Sole 4572Å line again plus band @ ~ 3720 (faint)
78042602	"	"	"	Same result, band even more faint
78042603	"	"	"	Cleaned S.T., IT and nozzle, prior line and band gone, others back

Run Number	Driver	Injection Tank	Oxidizer	Comments
78042604	150 psia	180 torr CO; 0.2 g Mg	200 psi N_2O	4572 now back! ??
78042701	"	180 torr N_2, No Mg	"	Black
78042702	"	180 torr N_2	-	Black, less light @ 4572 than prior shot
78042703	"	"	-	Black, trouble firing led to rebuild of trigger circuit
78050201-8	"	"	-	Firing tests, added PIN Diode looking in S.T. window
78050301-7	"	"	-	Conclusion of tests with PIN Diode with N_2
78050308-05	"	180 torr CO	-	Same but with CO
78050406-10	"	180 torr CO; 0.2 g Mg	200 psi N_2O	Only Mg 4572 line, no bands, $t_{ir} = .51 \rightarrow .55$
78050411	200 psia	"	"	Same spectrum, $t_{ir} = .50$
78050801	"	"	"	Beginnings of band structure, but no pressure record
78050802	150 psia	"	"	Remnants of bands, still no pressure record
78050803	"	20 torr CO; 160 Ar, 0.2 g Mg	"	Bright bands of AlO, weak MgO @ 3590, 3720Å + MgO B-X
78050804	"	"	"	Only weak continuum, still no pressure record, cleaned Kistler
78050805	"	180 torr CO; 0.2 g Mg	"	Brightest MgO B-X and $^3\Delta$-$^3\pi$, AlO; $t_{ir} = .46$
78050901-3	"	20 torr CO; 160 N_2, 0.2 g Mg	"	Only weak 4571 line; no pressure record
78050904	200 psia	"	"	4572 still weak - no bands, $t_{ir} = .50$ ms (really 200 psi?)

Run Number	Driver	Injection Tank	Oxidizer	Comments
78050905	200 psia	20 torr CO; 160 N_2; 0.2 g Mg	200 psi N_2O	t_{ir} = .45 ms, many lines and bands, MgO and AlO
78050906	150 psia	"	"	t_{ir} = .50 ms, very weak bands, lines strong
78051001	200 psia	"	"	No pressure record, lines and bands of MgO, AlO very faint
78051002	"	180 torr CO; 0.2 g Mg	"	$t_{ir} \cong .5$ ms, bright 4572, $^3\Delta-^3\pi$ only evident band
78051003	"	"	"	t_{ir} = .46 ms, 4572 line gone but allowed lines are strong
78051004	"	40 torr CO; 140 Ar; 0.2 g Mg	"	t_{ir} = .47 ms, MgO and Al0 bands, Mg and Al lines, cleaned ST
78051005	"	"	"	t_{ir} = .48 ms, brighter, CN B-X @ 3883 and less are brightest bands
78051101-2	"	180 torr Ar; 0.2 g Mg	"	t_{ir} = .48 ms; IO plate @ 2 cm, strong $^3\Sigma-^3\pi$, $^3\Delta-^3\pi$
78051103-4	"	20 torr CO; 160 Ar; 0.2 g Mg	"	t_{ir} = .47, .48; IO plate @ 3 cm, weaker MgO bands, stronger CN
78051105-6	"	50 torr CO; 130 Ar; 0.2 g Mg	"	t_{ir} = .48 ms, IO plate @ 4 cm, faint bands, weaker allowed lines, and 4572
78051107-8	"	180 torr CO; 0.2 g Mg	"	t_{ir} = .50 ms, IO plate @ 5 cm, strongest 4572 line, no allowed line
78051201	150 psia	20 torr CO; 160 Ar; 0.2 g Mg	"	t_{ir} = .52 ms, Polaroid spectrum has only allowed lines
78051202	200 psia	"	"	t_{ir} = .45 ms, CN B-X, MgO $^3\Sigma-^3\pi$, $^3\Delta-^3\pi$ very weak, allowed lines

Run Number	Driver	Injection Tank	Oxidizer	Comments
78051203	200 psia	20 CO; 100 Ar; 0.2 g Mg	200 psi N_2O	t_{ir} = .45, lines brighter and bands weaker
78051204	300 psia	20 CO; 160 Ar; 0.2 g Mg	"	t_{ir} = .45, lines brighter and bands weaker
78051205	"	20 CO; 100 Ar; 0.2 g Mg	"	t_{ir} = .44, same result
78071101	100 psia	200 torr Ar		First shot with new transition section
78071102	"	100 torr Ar		Black spectrum
78071103	"	10 torr Ar		Dense line spectra
78071201-4	"	20 torr Ar		$M_s \cong 8.3$, line spectra
78071205	"	50 torr Ar		Dense line spectra, repeatability problems evident
78071206	"	100 torr Ar		First run with deep cut driver diaphragm, $M \cong 4.0$
78071207-1306	"	80 torr Ar		$M_s = 4.7 - 5.1$, spectra
78071307	"	Ar/COS @ 79/1		Black
78071308	"	60 torr Ar		Weak line spectra
78071309	"	Ar/COS @ 59/1		No change - evident something is not correct!
78071310	"	60 torr Ar		Weak lines
78071311	"	COS/Ar @ 10/50		Ar loaded after COS, black
78071312	"	Ar/COS @ 55/5		COS loaded last, black
78071313	"	"		Ar and COS mixed while loading, black, but by M. C. much more

Run Number	Driver	Injection Tank	Oxidizer	Comments
78071314	100 psia	Ar/COS @ 20/2		Loaded in steps, first evidence of band structure
78071401	"	Ar/COS @ 30/3		Loaded first into DT, then tube, similar spectrum to 1314
78071402	"	Ar/COS @ ?		By opening slits and adjusting mirror, observe intense spectrum, M = 7
78-71403	"	50 torr Ar		Lines and weak background, M = 5.8
78 71414	"	80 torr Ar		Spex slit of 0.1 mm, M = 4.9; lines, continuum and bands
78071405	"	100 torr Ar		Lines plus weak bands, M = 4.6
78071406	"	Ar/COS @ 100/1		Ar introduced into D.T., lines and bands
78071407	"	100 torr Ar		Lines and weak bands
78071408	"	80 torr Ar		Bright lines and bands, M = 5.2
78071409	"	Ar/COS @ 78/2		Broad continuum and lines, loaded with both lines to D.T. and S.T., Ar first
78071410	"	COS/Ar @ 2/78		Lines and bands, COS loaded first - CONCLUDE need to premix
78071701	"	Mixing tank w/ 9 torr COS, 357 torr Ar		First shot with mixing tank, extremely bright
78071702	"	COS/Ar @ 3.6/360		28% ND filter, still white (on Polaroid) from 320-7500 nm
78071703	"	"		N.D. 2 filter, brightest bands are @ ~388 nm and below, CN??, M = 7.3
78071704	"	"		PMT now @ 800V, sharp rise and slow tail

Run Number	Driver	Injection Tank	Oxidizer	Comments
78071705	100 psia	1000 torr Ar		PMT @ 1KV, no signal, lines and weak bands, no filter, M = 4.8
78071706	"	COS/Ar @ 10/990		Bright band spectrum with no filter, 5 volts PMT signal
78071707	"	"		28% ND filter, diffuse band spectrum
78071801	"	"		Added vertical card to delete light from S.T. side of slit, weak
78071802	"	COS/Ar @ 20/1000		Spectrum still weak
78071803	"	COS/Ar @ 8/800		Spectrum still weak, M = 5.3
78071804	"	COS/Ar @ 5/500		Line spectrum, M = 6.3
78071805	"	COS/Ar @ 10/1000		Removed 28% ND filter, very nice cool spectrum, mirror on
78071806	"	COS/Ar @ 10/990		Card out, 28% ND filter in, get diffuse hot spectrum
78071807	"	"		Mirrors on both sides, ~ 0.1 volts on $\perp$ signal, no $\parallel$
78071808	"	"		M = 4.8, $\perp$ signal of 0.1 volt peak
78071809	"	"		
78071901-3	"	"		M = 4.9, $\parallel/\perp \cong .08/.08$
78071904	"	"		Spex side mirror blocked, $\parallel/\perp = .04/.06$
78071905	"	COS/Ar @ 8/800		M = 5.4, $\parallel/\perp = .04/.04$
78071906	"	COS/Ar @ 20/980		Spex side laser mirror out, $\parallel/\perp = .08/.1$

Run Number	Driver	Injection Tank	Oxidizer	Comments
78071907	100 psia	COS/Ar @ 40/960		Mirror still out, $\parallel/\perp$ = .06/.1
78071908	"	COS/Ar @ 6/600		Mirror still out, spectrum of S_2 + CN(?); $\parallel/\perp$ = .04/.05
78071909	50 psia	COS/Ar @ 5/500		Scopes did not trigger
78071910	"	COS/Ar @ 3/300		M = 5.8, very little light
78072001	100 psia	COS/Ar @ 10/990		M = 4.8, both mirrors on, path blocked
78072002	"	"		$\parallel/\perp$ = .04/.08
78072003	"	"		Both mirrors rotated 0.4 turn of thimble, $\parallel/\perp$ = .11/.08
78072004	"	"		0.8 turn, $\parallel/\perp$ = .11/.09
78072005	"	"		2.8 turns each $\parallel/\perp$ = .08/.05
78072006	"	1000 torr Ar		Using quadrant detector to measure laser beam deflection ≅ 10 mR
78072007	"	COS/Ar @ 10/990		5 turns each thimble, $\parallel/\perp$ = .06/.05
78072008	"	"		$\parallel/\perp$ = .05/.04
78072009	50 psia	COS/Ar @ 10/500		No laser mirror on Spex side and no card
78072010	"	COS/Ar @ 10/300		Same but for Argon, bright spectrum
78072011	"	COS/Ar @ 10/440		Added card, moderate cool spectrum @ M = 4.9

Run Number	Driver	Injection Tank	Oxidizer	Comments
78072012	50 psia	COS/Ar @ 10/440		Both laser mirrors on with thimbles turned 2 turns from ambient resonant, $\parallel/\perp \cong .02/.01$
78072013	"	"		Scope triggered early
78072101	"	"		Mirrors one turn from ambient resonant, scope triggered early
78072102	"	"		Same, $\parallel/\perp = .055/.04$
78072103	"	"		Blocked mirror, mis-triggered
78072104	"	"		Repeat, $\parallel/\perp = .02/.02$
78072105	"	"		Both thimbles two turns, $\parallel/\perp = .06/.05$
78072106	"	"		Thimbles to 2-1/2 turns, $\parallel/\perp = .09/.02$; $R \cong 4.5$
78072107	"	"		Thimbles 3 turns, $\parallel/\perp = .08/.02$
78072108	"	"		Thimbles @ 2.6 turns, $\parallel/\perp = .06/.02$